The California Water Plan Update 2005 is organized in five volumes:

Volume 1: Strategic Plan
Volume 2: 25 Resource Management Strategies
Volume 3: 12 Regional Reports
Volume 4: Reference Guide (60+ articles)
Volume 5: Technical Guide (Online documentation)

The final California Water Plan Update 2005 and the Water Plan Highlights briefing book were completed in December 2005. The five volumes of the update, the Highlights document, and the introductory video, “Water for Tomorrow,” are contained on the CD and DVD below and also available online at www.waterplan.water.ca.gov.

Printed copies are available. The Highlights briefing book, which contains the CD and DVD, is available at no charge. Volume 1, 2, and 3 are $15 each. Volume 4 is $50. For printed copies, contact:

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Cover photographs: DWR Graphic Services, Photography Unit.

Cover design: Chris Sanchez.
State of California
The Resources Agency
Department of Water Resources

California Water Plan Update 2005
A Framework for Action

Bulletin 160-05
December 2005

Arnold Schwarzenegger
Governor
State of California

Mike Chrisman
Secretary for Resources
The Resources Agency

Lester A. Snow
Director
Department of Water Resources
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Introduction

As if three volumes on California water resources weren’t enough, here’s yet a fourth. In contrast to previous Water Plan Updates, this time around we have consolidated the most important messages of California Water Plan Update 2005 in Volume 1, so as not to burden those messages with the many details and nuances of California water planning. But for those of you who live and breathe for complexity, Volume 4 is for you. In the following pages of what we informally call the “Encyclopedia Water Plan,” DWR provides a more transparent and extensive look at many of the issues presented already in the foregoing three volumes.

As you will soon see, the Encyclopedia Water Plan is formally divided into the following subject categories for easy indexing: Background; Crop Water Use; Data and Analytical Tools; Environment; Environmental Justice; Global Climate Change; Hydrology; Infrastructure; Landscape Water Use; Legislation; Litigation; Planning; Tribal History and Consultation; and Water Quality. At the end of Volume 4, you will also find a rather nifty glossary for your use while reading all four volumes of the Water Plan Update. But beyond these strict categories, the articles contained herein fall more generally into the following three areas.

- **Background on California water resources.** So, when did the St. Francis Dam fail? What’s the background and current status of the Monterey Agreement litigation? In surveying Water Plan Update users, many responded that they frequently turn to the document for this good, basic information on water resources in California.

- **Water resources analysis.** Trying to figure out water resources in California is hard work, and many of the following articles provide the reader with an in-depth discussion of some of the complex issues with which State, regional, and local planners grapple. These articles focus on planning techniques, “data and tools” for water resources evaluation, and just about everything you ever wanted to know about evapotranspiration.

- **Emerging issues in California water resources.** The Water Plan Update previews many water resources issues that are just emerging and/or growing in concern. They include climate change, environmental justice, the integration of land use and water resources in planning, the future of California agriculture, and the potential for water use efficiency in the environmental sector. DWR expects that many of these subjects could take a larger role in the next Water Plan Update.

Not every article suggested or even submitted for the Reference Guide was accepted for publication. To be included, an article needed a direct link to an issue in one of the other three volumes of the document, and, in fact, had to provide more substantive background or discussion of that issue. Articles had to be reasonably objective (even those with bylines) and well written. For the most part, the Water Plan Advisory Committee and DWR staff were the primary sources of ideas for Reference Guide articles.

So, we invite you to choose, read, and enjoy those articles in which you are interested. We are, of course, obligated to close by noting that these articles contain solely the views of the authors themselves, and do not necessarily reflect the views of the Department of Water Resources or the Water Plan Advisory Committee.

--John T. Andrew, Editor
Background

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The Advisory Committee View
By the California Water Plan Update 2005 Public Advisory Committee
### THE ADVISORY COMMITTEE VIEW

June 2005

This California Water Plan Update 2005, the eighth since 1957, comprehensively reviews the state’s water problems and opportunities. Like California, the plan update has changed since 1957. A growing population, increased pressures on our natural environment, concerns about drinking water quality, costs, and many unknowns including climate change are now water planning considerations.

A diverse group of people assisted in developing the plan by serving on an Advisory Committee. The group represented organizations and interests concerned with water resources management. Some of us, including Native Americans and environmental justice groups, had not been represented in past advisory committees. Knowing the plan was DWR’s, not ours; we shared suggestions and concerns and posed tough questions. We served as advisors.

As a group, we agreed on many things, but not everything. We expected this. This document explains things we mostly agreed about, describes where we do not agree, and notes the places we still have questions.

We encourage you to read the Public Review Draft thoroughly, participate in the public review process, and offer your comments. This solid planning effort deserves your attention.

### IMPORTANT INFORMATION ABOUT THIS DOCUMENT

This document offers the many perspectives of the Water Plan Update appointed Public Advisory Committee. It does not represent a policy or view of the DWR, the facilitators or any individual Public Advisory Committee member or member organization. The sole purpose of this document is to share the differing perspectives of the Advisory Committee in order to help the public understand more about the deliberations leading to the Water Plan Update.

### AREAS OF SUBSTANTIAL AGREEMENT

Members of the Advisory Committee generally agreed about **Using a different approach than in the past.** The plan was developed with a large, diverse, and vocal Advisory Committee and tended public involvement. Computer technology helped DWR keep Advisory Committee members and the public up-to-date and informed. Activities and information related to the plan can easily be found at [http://www.waterplan.water.ca.gov/](http://www.waterplan.water.ca.gov/).

**Using the document as both a policy guiding strategic plan and a source of technical information.** The Advisory Committee felt a strategic plan, as opposed to a pure technical plan, would help Californians better plan and assess state water management.

**A need for more information than is now available.** We worked with DWR to create a phased work plan. The Plan outlines a schedule to develop improved analytical tools and data. Most desired new work will be completed as part of a 3-phase work plan. The group believes this will help DWR meet Water Code and other legal requirements in the next update. The information will also help local and regional agencies with integrated water resource planning and management. Phased work plan details are found on page 1-5 of Volume 1: Strategic Plan.

(Continued on page 2 …)
THE PLAN INCLUDES IMPORTANT NEW FEATURES

- More complete and detailed information on actual water flows than were available in previous plans. Called water portfolios, water use categories and water supply information span a full hydrologic cycle (wet, dry and average).
- Except for agricultural trends, use of historic data instead of projections based on current conditions. This information creates an appreciation for California’s complex and variable water flows.
- Regional analysis and reports identify unique challenges and specific ongoing programs and plans. Water management is mostly local and regional. Regional reports allow a clearer focus on these problems, within a statewide context.
- Multiple future scenarios (recognizing that uncertainty over the next 30 years makes a single, likely future impossible to present). Numerous events and choices, many unrelated to water planning, may drive the future.
- A focus on integrated regional water management as a key strategy and use of a full range of water management tools. There is no single solution to California’s water problems. Local, regional, and statewide integration of multiple solutions will be required.
- The plan outlines methods for data analysis and scenario development to be used in future updates.

MORE AREAS OF AGREEMENT

(Continued from page 1)

Clear mission and vision statements, five high-level goals, fourteen recommendations, and specific action items for each of the fourteen recommendations. Other strong points are identification of implementation challenges, as well as performance measures to track progress. This provides a strategic roadmap. It is a call to action.

Clear statements on essential support activities. The plan calls on the state to provide leadership, establish credible and reliable financing mechanisms, clarify the authorities and responsibilities of different entities in the water community, invest in water technology, and ensure that equitable decisions are made to provide for fair treatment of low-income people and disadvantaged communities of color in California. One goal is better application of environmental justice criteria and greater inclusion of underserved communities in planning and decision making, with special sensitivity to the unique obligations to Native American communities.

The presentation of links to CALFED, that recognize the role the CALFED Bay-Delta Program plays in overall California water issues.

The importance of water quality to protecting California’s waters.

The presentation of a good balance between data and policies.

Incorporation of information from the state’s General Plan Guidelines to promote a better link between water supply planning and local land use planning.

The Water Plan contains a responsible chapter on climate change.

AREAS OF DISAGREEMENT AMONG ADVISORY COMMITTEE MEMBERS

Sometimes the Advisory Committee did not agree with DWR and/or one another on various aspects of the plan. It has been difficult for DWR to address the sometimes-competing interests of the Advisory Committee members. To some extent this represents different philosophical approaches to dealing with California water problems. The following explains these disagreements in more detail.

- New surface storage, linked to the CalFed program. There were a variety of reasons for this disagreement.
- The group disagrees about the utility, cost-effectiveness, and need for additional surface storage and whether adequate water supply can be provided by the measures described. Some believe there is a need for more storage than the plan recommends while others believe water conservation and efficiency are much better alternatives than expanding infrastructure. The group also disagreed as to how much ecological damage occurs and/or should be tolerated in development of additional water supply.
- Some believe the plan underestimates implementation challenges and suggest more evaluation.
**Disagreements (continued from page 2)**

- There is disagreement about the contribution of agriculture to the overall water efficiency estimates for 2030. Some believe the estimates for water savings for agriculture appear very low. Others believe the agricultural industry has already voluntarily adopted efficiencies shown to improve return on investment, and/or that agriculture is very efficient now within nearly all hydrologic regions due to extensive re-use of agricultural return flows. Some believe numbers for all water use efficiency (not just agricultural) approaches overestimate the potential.

- There are legal requirements for the document. One law requires DWR to make assessments of water needed for the provision of food and fiber to the population. DWR held off in this assessment, waiting for the results of a study to be conducted by another state agency. This study did not occur and DWR provided an interim response to the legislative requirement in the Volume 4: Reference Guide. Some members of the group strongly disagreed with the interim findings and approach.

- Another law requires DWR to provide a gap analysis of predicted water need versus predicted available water. Given the potential for multiple options, the plan instead addressed multiple uncertainties and recommends more complex modeling and other analytical tests than now available. The plan also outlines development of future water use and water supply scenarios. Some find this approach does not meet legal requirements for this document.

- Some believe the plan pushes too hard for market-based solutions to allocating or deciding who gets water when the supply cannot meet all demands. Some believe this could preclude agriculture or the environment from receiving water. Others suggest the plan needs to address long-term socioeconomic issues associated with water transfers. Still others believe changes could compromise historic public legal water rights. Some believe the plan needs to address long-term socioeconomic issues associated with water transfers and not merely ignore these issues.

- Some contend DWR’s data as presented in the plan support approaches that are less infrastructure-intensive in nature and feel that the plan is deficient for not including a third Initiative for Reliability that directs the state to actively pursue those approaches.

- Others point to DWR data that suggests the major source of "new water" for the state will come through conservation and efficiency measures and that "water efficiency" should be elevated and defined as one of the Initiatives of the Plan. Several others think that the numbers underestimate the potential of water use efficiency approaches. The data and analyses for water use efficiency in the plan are the subject of much debate (as are all the numbers).

**UNCERTAINTIES IN THE PLAN**

1. Funding at the federal, state and local levels is severely restricted with serious consequences if recommended actions are not funded.

2. Actions to sustain water supply reliability are directed by local water agencies but the plan does not identify mechanisms to enforce or induce action.

3. The focus on integrated regional water management is positive but the document does not address state leadership to support and oversee the regional process nor how interregional conflicts will be handled.

4. The update relies in part on the beneficiaries of water being the primary funders of new infrastructure. There is no definition of the term beneficiary. There is a need to outline how the beneficiaries pay principle is to be implemented.

5. Some express concern the plan does not address how regions will determine if they will collectively develop enough water both to meet the water needs of their local population and to produce food and other commodities needed by humanity at large.

6. There is no specific mechanism to measure whether or not implementation of the plan or individual recommendations was successful.

7. The scenarios will need more development for decision makers to determine viability of the proposed options.
Members of the Public Advisory Committee
for the California Water Plan – Update 2005

Margit Aramburu - Delta Protection Commission
Mary Bannister - Pajaro Valley Water Management Agency
Kirk Brewer - California Water Association
Merita Callaway - California State Assoc. of Counties
Scott Cantrell - California Dept. of Fish and Game
Grace Chan - Metropolitan Water Dist. of Southern CA
   Alternate: Don Bentley
Jim Chatigny - Mountain Counties Water Resources Association
Marci Coglianese - League of California Cities
   Alternate: Dan Secord, M.D.
Bill Cunningham - Natural Resources Conservation Service
   Alternate: Luana Kiger
Grant Davis - Bay Institute of San Francisco
Martha Davis - Inland Empire Utilities Agency
Mary Ann Dickinson - CA Urban Water Conservation Council
   Alternate: Katie Shulte-Joung
Nick Di Croce - California Trout
Anisa Divine - Imperial Irrigation District
William DuBois - California Farm Bureau Federation
   Alternate: John Hewitt
Howard Franklin - Monterey County Water Resources Agency
Lloyd Fryer - Kern County Water Agency
Bill Gaines - California Waterfowl Association
   Alternate: Mark Hennelly
Fran Garland - Contra Costa Water District
Peter Gleick - Pacific Institute for Studies in Development, Environment, and Security
Zeke Grader - Pacific Coast Federation of Fishermen’s Associations
Brent Graham - Tulare Lake Basin Water Storage District
David Guy - Northern California Water Association
   Alternate: Todd Manley
Martha Guzman - United Farm Workers of America
Alex Hildebrand - South Delta Water Agency
Mike Hoover - U.S. Fish and Wildlife Service
Bill Jacoby - WateReuse Association
Craig Jones - State Water Contractors, Inc.
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   Alternate: Teri Cawelti
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John Mills - Regional Council of Rural Counties
Clifford Moriyama – California Business Properties Association
Eric Natti - California Dept. of Parks & Recreation
Valerie Nera - California Chamber of Commerce
James Noyes - Southern CA Water Committee, Inc.
   Alternate: Alallen Gribnau
Elaine Quitiquit-Palmer – Robinson Rancheria
Enid Perez - Del Rey Community Services
Lloyd Peterson - U.S. Bureau of Reclamation
   Alternate: Al Candlish
Cathy Pieroni - City of San Diego Water Department
Nancy Pitigliano - Tulare County Farm Bureau
   Alternate: Cheryl Lehn
Betsy Reifsneider - Friends of the River
Terry Roberts - Governor’s Office of Planning and Research
Larry Rohlfes - CA Landscape Contractors Association
Spreck Rosekrans - Environmental Defense
   Alternate: Ann Hayden
Jennifer Ruffolo - California Research Bureau
Steve Shaffer - California Department of Food and Ag.
Polly Osborne Smith - League of Women Voters of CA
Jim Snow - Westlands Water District
Frances Spivy-Weber - Mono Lake Committee
John Sullivan - League of Women Voters
Walter Swain - U.S. Geological Survey
Greg Thomas - Natural Heritage Institute
   Alternate: Rich Walkling
Michael Wade - California Farm Water Coalition
Michael Warburton - The Ecology Center of Berkeley
Arnold Whitridge - Trinity County
Robert Wilkinson - Univ. of California, Santa Barbara
Kourt Williams - Executive Partnership for Environmental Resource Training
Carolyn Yale - U.S. Environmental Protection Agency
Gary Yamamoto - California Dept. of Health Services
Tom Zuckerman - Central Delta Water Agency
Bay Delta Standards Contained in D-1641
Bay Delta Standards

*By DWR Staff*
# Bay-Delta Standards

**Flow/Operational**

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**Water Quality Standards**

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| All Export Locations | | | | | | | | | | | | | ≤ 250 mg/l Cl
| Contra Costa Canal | | | | | | | | | | | | | 150 mg/l Cl for the required number of days

| Agriculture | | | | | | | | | | | | |
| Western/Interior Delta | | | | | | | | | | | | | Max 14-day average EC mmhos/cm
| Southern Delta | | | | | | | | | | | | | 1.0 mS

| Fish and Wildlife | | | | | | | | | | | | |
| San Joaquin River Salinity | | | | | | | | | | | | | 14-day avg 0.44 EC
| Suisun Marsh Salinity | | | | | | | | | | | | | 19.9 EC

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**Footnotes**

- See Footnotes
- [Operations Compliance and Studies Section](#)
- [Revised 9/29/00](#)
- [Preliminary: Subject to Revision](#)
The maximum percent Delta inflow diverted for Feb may vary depending on the January 8RI. When no date is shown, EC limit continues from April 1.

PULSE: Vernalis minimum monthly average flow rate in cfs. Take the higher objective if X2 is required to be at or west of Chipps Island.

Rio Vista minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 1,000 below the monthly objective).

For the Nov-Jan period, Delta Cross Channel gates may be closed for up to a total of 45 days. Critical year following a critical year. Time period based on real-time monitoring and determined by CalFed Op’s group.

Take the higher objective if X2 is required to be west of Chipps Island.

BASE: Vernalis minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 20% below the objective).

Maximum 3-day running average of combined export rate (cfs) which includes Tracy Pumping Plant and Clifton Court Forebay Inflow less Byron-Bethany pumping.

Maximum 3-day running average of combined export rate (cfs) which includes Tracy Pumping Plant and Clifton Court Forebay using a 3-day average. These percentages may be adjusted upward or downward depending on biological conditions, providing there is no net water gain.

TABLE A

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<td>0.74</td>
<td>1.0</td>
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</tr>
<tr>
<td>Feb</td>
<td>1.14</td>
<td>0.74</td>
<td>1.0</td>
<td>0.58</td>
</tr>
<tr>
<td>Mar</td>
<td>1.67</td>
<td>1.35</td>
<td>1.0</td>
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During deficiency period, the maximum monthly average mhtEC at Western Suisun Marsh stations shall be 1.0 EC until

Operations Compliance and Studies Section

Revised 12/2004

Preliminary - Subject to Revision

Bay Delta Standards Contained

Volume 4
A California Water Chronology
By the Water Education Foundation
A California Water Chronology

In 2000, California celebrated its sesquicentennial (150 years of statehood). Within this relatively short time, the State's major water infrastructure and complex institutional framework for managing water were developed. The following chronology highlights some key points in California's water history.

1848 Treaty of Guadalupe Hidalgo transfers California from Mexico to the U.S.
1848 Gold is discovered at Sutter's Mill on the American River.
1850 California is admitted to the Union.
1871 First reported construction of a dam on Lake Tahoe.
1884 Hydraulic mining is banned because of its impacts on navigation and contribution to flooding.
1886 Lux v. Haggin addresses competing water rights doctrines of riparianism and prior appropriation.
1887 Legislature enacts Wright Irrigation District Act, allowing creation of special districts.
1887 Turlock Irrigation District becomes first irrigation district formed under the Wright Act.
1895 World's first long-distance transmission of electric power (22 miles), from a 3,000 kW hydropower plant at Folsom to Sacramento.
1902 Congress enacts the Reclamation Act of 1902, creating the Reclamation Service, and authorizing federal construction of water projects.
1905 Salton Sea is created when the Colorado River breaches an irrigation canal and flows into the Salton Trough.
1913 First barrel of Los Angeles Aqueduct completed.
1914 California's present system of administering appropriative water rights is established by the Water Commission Act.
1922 Colorado River Compact signed.
1928 California Constitution amended to prohibit waste of water and to require reasonable beneficial use.
1928 Saint Francis Dam fails.
1929 State dam safety program goes into effect.
1929 East Bay MUD's Mokelumne River Aqueduct is completed.
1934 San Francisco's Hetch Hetchy Aqueduct is completed.
1940 All American Canal is completed.
1941 Colorado River Aqueduct is completed.
1945 Shasta Dam is completed.
1957 The Department publishes Bulletin 3, the California Water Plan.
1960 California voters approve the Burns-Porter Act, authorizing the sale of bonds to finance State Water Project construction.
1968 Oroville Dam is completed.
1969 Legislature enacts Porter-Cologne Act, the foundation of California water quality regulatory programs.
1973 California Aqueduct is completed.
1978 California v. U.S. held that the U.S. must obtain water rights under State law for reclamation projects, absent clear congressional direction to the contrary.
1978  SWRCB issues Decision 1485, requiring the CVP and SWP to meet specified Bay-Delta operating criteria.
1983  National Audubon Society v. Superior Court sets forth the application of public trust concepts to water rights administered by SWRCB.
1992  Congress enacts the Central Valley Project Improvement Act (PL 102-575).
1994  SWRCB issues Decision 1631, requiring specified protections for Mono Lake levels.
1994  Bay-Delta Accord signed; its original three-year term extended to a total of four years.
1995  CALFED Bay-Delta Program to develop a comprehensive, long-term program for environmental protection of the Bay-Delta System and Water Supply and reliability for all water users. CALFED was charged with planning, selecting, and implementing this long-term solution.
1996  Monterey Amendments litigation filed against DWR. (Planning and Conservation League vs. Department of Water Resources and Central Coast Water Authority)
1997  Silverwood Lake celebrates Grand Reopening after the completion of new intake structure.
2000  CALFED publishes Programmatic Record of Decision
2002  Statement of principles for settlement of the Monterey Amendments litigation.
2003  Inaugural meeting of the California Bay-Delta Authority, formerly known as CALFED. CBDA specifically is charged with ensuring balanced implementation of the CALFED Record of Decision.

Colorado River Quantification Settlement Agreement and Salton Sea ecosystem restoration legislation create new responsibilities for the Resources Agency and for the Departments of Fish and Game and Water Resources.
A Look Back at Past California Water Plans
A Look Back at Past California Water Plans

The California Water Plan (1957)

The California Water Plan was the final of a series of three bulletins setting forth the results of statewide water resources investigations that had begun in 1947. Bulletin No. 3 described a comprehensive master plan for the control, protection, conservation, distribution, and utilization of the waters of California, to meet present and future needs for all beneficial uses and purposes in all areas of the state to the maximum feasible extent. It was an ultimate plan that indicated the general manner in which California's water resources should be developed to satisfy the potential ultimate water requirements of the State. It did not give consideration to time or economics, either in staging of projects or in the growth of demand for water and associated services. It was to be regarded as a broad and flexible pattern into which future definite projects may be integrated in an orderly fashion. Additional data and experience not foreseen in 1957 would substantially alter and improve The California Water Plan. The basic concept of the Plan as a master plan to meet the ultimate requirements for water at some unspecified but distant time in the future, when the land and other resources of California have essentially reached a state of complete development, would remain unchanged. It was to be implemented by a statewide program for the construction of projects needed to control and supply water wherever and whenever the need arises and as projects are found feasible. The job would require the combined efforts of the federal government, State government and local agencies, as well as private entities and individuals, with the State taking a leading role in administration and coordination as well as financing and construction. The base year for Bulletin No. 3 was 1950.

Statewide planning studies to update the California Water Plan have continued since 1961, and have incorporated economic considerations. Results of the studies have been presented in the Bulletin 160 series of reports.

Implementation of the California Water Plan (1966)

The first of the Bulletin 160 series, Bulletin No. 160-66 reported on studies conducted within the framework of The California Water Plan and outlined the manner by which progress should be made from the present (1960) to the stage of development that would meet the state's 2020 demands. It included the best available information on water demand forecasts throughout the state and on economic considerations involved in the staging of water supply and delivery projects. It identified some of the more favorable projects and presented a schedule for the staging of those projects to meet the increasing water demands. Bulletin No. 160-66 was neither an alternative nor a replacement of Bulletin 3, but rather a proposed pattern for implementation of specific parts of The California Water Plan, as set forth by the California Water Code.

Some water policy concerns discussed included flood control and floodplain management, power demands, water-related recreation, the relationship of fish and wildlife to water development, and water quality.
Water for California: The California Water Plan; Outlook in 1970

By 1967 California's population had grown to 19 million, but the rate of growth had slowed from that of the 1950s. In this Bulletin No. 160-70 population projections for 1990 and 2020 were reduced. Irrigated acreage estimates were also reduced, and more accurate information on the consumptive use of crops and the extent of water reuse was available. With projects then under construction or authorized, the report concluded that sufficient water supplies would be available to meet most of the 1990 requirements. The report concluded that the projected slower population growth, together with additional water supplies under development or authorized, would provide a breathing spell that would allow more time "... to consider alternative sources of water supply and develop policies for the maximum protection of the environment." The trend toward increasing environmental awareness was noted for both the national and state levels.

The California Water Plan: Outlook in 1974

By 1972, the base year for Bulletin 160-74, the state's population had reached about 21 million, indicating a continuing slowdown in the rate of growth. Population projections were again revised downward for 1990 and 2020 to 27 million and 37 million, respectively. This report concluded that the status of available supplies, compared to the (then) present use, was favorable. This was based on the premise that the Auburn, New Melones, and Warm Springs Reservoirs and the Peripheral Canal would be operational by 1980. But it was less conclusive about the extent to which supplies would satisfy future needs, considering new California legislation for wild and scenic rivers, primarily on the North Coast. Key water policy issues discussed were cooling water for electric energy production, water deficiencies (risk), water exchanges, public interest in agricultural drainage (San Joaquin Drain), water use efficiency (water conservation), economic efficiency (water transfers), and waste water reclamation.

This issue of the Bulletin 160 series departed from the earlier practice of a single forecast of future water use by presenting four different scenarios as to future conditions and events that affect water use.


Bulletin 160-83 presented some of the alternative sources of supplies or potential shortages associated with future uses to 2010. More a technical report than previous editions, part of the process included the development of agricultural models applied for the first time. These were used in assessing the general economic effects of increasing water and energy costs. The report quantified the effect of urban and agricultural water conservation measures and the potential for water reclamation as a means of reducing water needs. A number of non-structural options for making more effective use of water supplies were proposed for further consideration.


Looking back to the previous four reports in the Bulletin 160 series, Bulletin 160-87 described them as technical examinations of the then-current water supplies and water demand for coming decades. The
1987 report took a broad view of water events and issues in California, and examined how California can continue to meet the water needs of a continually growing population. The report also discussed several leading water management concerns including water quality, the Sacramento-San Joaquin Delta, and evolving water policies over a wide range. One of its main conclusions was that in roughly three out of four years, California's natural water resources, including rights to the Colorado River, were sufficient to meet all of its water needs for the foreseeable future.

**California Water Plan Update: Bulletin 160-93 (1994)**

More than 35 years after the first California water plan was published, this report discussed how population growth, land use, and water allocations for the environment were affecting water resource management. The bulletin discussed the effects of more stringent water quality standards, the Endangered Species Acts, the Central Valley Project Improvement Act of 1992, and efforts to solve problems in the San Francisco Bay-Sacramento-San Joaquin River Delta estuary. It differed from the five previous water plan updates by: (1) estimating environmental water needs separately and accounting for these needs along with urban and agricultural water demands; (2) presenting water demand management methods as additional means of meeting water needs; and (3) presenting separate water balance scenarios for average and drought conditions.

This was the first of the Bulletin 160 series to incorporate an advisory committee of representatives of interested parties. The base year for analysis was 1990, and 2020 was the planning horizon.


In response to public comments on the previous Bulletin 160, the 1998 issue evaluated water management options that could improve California's water supply reliability. Water management options being planned by local agencies form the building blocks for evaluations performed for each of the state's ten hydrologic regions. Potential local options were integrated with options of a statewide scope, such as the CALFED Bay-Delta Program, to create a statewide evaluation. Bulletin 160-98 estimated a 1.6 million acre-feet water shortage in average years at the 1995 level of development, and a 5.1 maf shortage in drought years.

**Previous California Water Plans (before 1957)**

In addition to reports mentioned above, there were at least three major California water plans before Bulletin No. 3 in 1957.

1874 – *First Water Plan for California, for developing irrigation in the Central Valley*

“The Report of the Commissioners on the Irrigation of the San Joaquin, Tulare, and Sacramento Valleys, in the State of California” was published in 1874 as a report to the 43rd Congress. The report was reprinted in 1990 by the Office of History of the U.S. Army Corps of Engineers. The report reviews irrigation methods, laws, and institutions worldwide as part of creating a plan for developing the Central Valley for irrigation. The authors were two employees of the U.S. Army Corps of Engineers and one from the U.S. Coast Survey.
1919 – California’s “Marshall Plan” for Water

Pisani (1984) discusses the work of Robert Bradford Marshall, a USGS employee based at the University of California, who developed a plan for diverting water from northern rivers to southern basins and the San Francisco area. This plan became the precursor of the first State Water Plan in 1930. (D.J. Pisani (1984), From Family Farm to Agribusines: The irrigation crusade in California and the west 1850-1931, University of California Press)

1930 – First State Water Plan

The “State Water Plan 1930” was presented to the California Legislature of 1931 as Bulletin No. 25 of the Division of Water Resources of the California Department of Public Works. This is the direct precursor of the Central Valley Project and the 1957 California Water Plan.
Selected Task Force and Advisory Panels
**Selected Task Forces and Advisory Panels**

**Governor’s Advisory Drought Planning Panel’s Critical Water Shortage Contingency Plan**

In response to the commitment in the CALFED Bay-Delta Program’s Record of Decision, the Governor convened a panel to develop a “contingency plan to reduce the impacts of critical water shortages primarily for agricultural and urban water users.” Panel members met four times between late August and December 2000 to hear informational briefings and to develop the contingency plan. The panel recommended 16 actions within broader categories:

- DWR should implement a Critical Water Shortage Reduction Marketing Program, building on experience gained from DWR’s past drought water banks. The program would be operated as a water purchasing and allocation program. DWR would acquire options to purchase water from willing sellers and would exercise the options as needed to make water available for sale to water users experiencing critical water shortages.
- DWR should provide technical assistance and educational programs to small water systems and homeowners in rural counties.
- DWR should establish an AB 3030 technical assistance program and update Bulletin 118 to provide improved groundwater data.
- DWR and other CALFED agencies should work in partnership with local water agencies to assist them in developing plans to facilitate integrated management of supplies for agricultural, urban, and environmental purposes.
- DWR should identify and seek funding for research in the areas of long-range weather forecasting, global climate change, and paleoclimatology. DWR should also develop regional hydrologic drought indices to help in statewide monitoring and develop a public outreach program to stress the need for drought preparedness.
- The Governor should take all possible actions to ensure rapid disbursement of Proposition 13 funds and that DWR maximize the use of grants, rather than capitalization loans, to bring local agencies up to the base level of water use efficiency contemplated in the CALFED ROD.

**Floodplain Management**

- Floodplain management includes actions to the floodplain to reduce losses to human resources within the floodplain and/or protect benefits to natural resources associated with flooding. For example:
  - Minimizing impacts of flows
  - Maintaining or restoring natural floodplain processes
  - Removing obstacles within the floodplain voluntarily or with just compensation
  - Keeping obstacles out of the floodplain
  - Educating and emergency preparedness planning
  - Ensuring that operations of floodwater management systems are not compromised by activities that interfere with, or are damaged by, design floods of these systems.

**Stormwater Management Quality Task Force Recommendations**

The California Stormwater Quality Task Force was formed in 1989 to assist the State Water Resources Control Board in implementing the National Pollutant Discharge Elimination System Stormwater Program in California. Some of the task force work products include:
• Revision of California Best Management Practices Handbooks
• Input to regulatory initiatives on pesticides, permitting
• Public education and outreach
• Best management practice guidance

California Floodplain Management Task Force Recommendations

In an effort to reduce the impacts of flooding through better coordination of floodplain management, Assembly Bill 1147 recommended establishment of a Floodplain Task Force. The California Floodplain Management Task Force was established in early 2002 to examine specific issues related to State and local floodplain management. The Task Force, a diverse group of private, non-profit, and local interest groups and State, federal, and local agencies, created more than 30 recommendation for improved floodplain management. Recommendations then grew from three basic themes:

• Better Understanding and Reducing Risks from Reasonably Foreseeable Flooding. Local, State and federal agencies should consider the risk to life and property from reasonably foreseeable floods when making their land use and floodplain management decisions. To do this effectively, decision-makers need better tools and information and specific methods to comply with the federal National Flood Insurance Program (NFIP).

• Multi-Objective Management Approach for Floodplains – Multi-Objective Management Approach for Floodplains. State, local and federal agencies should implement multi-objective floodplain management on a watershed basis. Where feasible, projects should provide adequate protection for natural, recreational, residential, business, economic, agricultural, and cultural resources, and protect water quality and supply.

• Local Assistance, Funding, and Legislation for Floodplain Management. DWR should identify and actively pursue funding opportunities, technical assistance to local governments and other organizations, and legislative proposals to implement Task Force recommendations and ensure successful floodplain management, recognizing that local governments have the primary responsibility and authority for land use decisions.

The Reclamation Board of the State of California endorsed the California Floodplain Management Task Force Report on December 20, 2002. Floodplain use can influence water supply reliability including water quality.

Governor’s Commission on Building for the 21st Century

Governor Gray Davis convened a commission to consider the challenge of investing in the infrastructure of California for the 21st Century. The commission was directed to “study the building and infrastructure needs of California, with the intent of identifying existing critical infrastructure needs and developing a comprehensive long-term capital investment plan for financing public building needs, including responsible financial approaches and efficiency improvements.” The commission’s interim report in August 1999 outlined findings and recommendations for facilities, natural resources, technology and transportation. The commission recommended a $3 billion bond for critical resources including water, parks, and open space.
State Recycling Task Force Recommendations

Assembly Bill 331 would require the Department of Water Resources to convene the 2002 Recycled Water Task Force with specified membership to advise the department in investigating the opportunities for using recycled water in industrial and commercial applications and in identifying impediments and constraints to increasing the industrial and commercial use of recycled water, and would require a report to the Legislature with recommendations on specified topics not later than July 1, 2003.

The Task Force identified and adopted 26 issues with respective recommendations to address obstacles, impediments, and opportunities for California to increase its recycled water usage. Among the key findings, possibilities of enhanced use of recycled water in landscape irrigation of highway medians, golf courses, parks, and schoolyards; industrial uses such as power station cooling towers, oil refinery boiler feed water, carpet dyeing, recycled newspaper processing, laundries; and agricultural uses such as irrigation of produce, pastures for animal feed, and nursery plant products and in office buildings for toilet flushing would lead to save fresh water. The task force concluded that California has the potential to recycle up to 1.5 million acre-feet per year by the year 2030. This could free up freshwater supplies to meet approximately 30 percent of the household water needs associated with projected population growth. However, to achieve that potential, Californians will have to invest nearly $11 billion (approximately $400 million annually) for additional infrastructure to produce and deliver the recycled water.

State Watershed Management Guidelines and Initiative

Assembly Bill 2117 (Wayne, Chapter 735, Statutes of 2000) required a report to the Legislature on California’s watershed status and any needed changes in State laws. The State Secretary for Resources and Chair of the State Water Resources Control Board formed the Joint Task Force on California Watershed Management, an interagency and stakeholder effort, to discuss the results of 10 case studies, to refine the findings, and to craft major recommendations to move the State in a new direction to protect and restore watersheds, lakes, rivers and estuaries in California. The Task Force’s April 2002 report, Addressing the Need to Protect California’s Watersheds: Working with Local Partnerships, contained six major recommendations.

Water Desalination Task Force

This Assembly Bill would require the Department of Water Resources, not later than July 1, 2004, to report to the Legislature, on potential opportunities and impediments for using seawater and brackish water desalination, and to examine what role, if any, the state should play in furthering the use of desalination technology. The bill would require the department to convene a Water Desalination Task
Force, comprised of representatives from listed agencies and interest groups, to advise the department in carrying out these duties and in making recommendations to the Legislature.

The Task force came up with 41 key findings and 29 major recommendations. Among these it was identified that desalination can provide significant value and numerous benefits. These include:

- Providing additional water supply to meet existing and projected demands
- Replacing water lost from other sources and relieving drought conditions
- Enhancing water reliability and supplying high quality potable water
- Reducing groundwater overdraft and restoring use of polluted groundwater
- Replacing water that can be used for river and stream ecosystem restoration
Selected Water Prices in California
**Selected Water Prices in California**

Estimated State Water Project Contract Unit Water Charges by Service Area

<table>
<thead>
<tr>
<th>Service Area</th>
<th>2003 Estimated Unit Cost ($/AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feather River</td>
<td>37</td>
</tr>
<tr>
<td>North Bay</td>
<td>178</td>
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<tr>
<td>South Bay</td>
<td>161</td>
</tr>
<tr>
<td>Coastal</td>
<td>629</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>74</td>
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<tr>
<td>Southern California</td>
<td>277</td>
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Source: DWR B132-02

Central Valley Project Contract Water Charges by Selected Facility

<table>
<thead>
<tr>
<th>Facility</th>
<th>2005 Contract Rate Range ($/AF)</th>
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<tbody>
<tr>
<td></td>
<td>Urban</td>
</tr>
<tr>
<td>Sacramento River</td>
<td>9 - 19</td>
</tr>
<tr>
<td>Corning Canal</td>
<td>n/a</td>
</tr>
<tr>
<td>Tehama-Colusa Canal</td>
<td>23</td>
</tr>
<tr>
<td>San Felipe Unit</td>
<td>43</td>
</tr>
<tr>
<td>Delta-Mendota Canal</td>
<td>15 - 36</td>
</tr>
<tr>
<td>San Luis Canal</td>
<td>27 - 64</td>
</tr>
<tr>
<td>Friant-Kern Canal</td>
<td>10 - 27</td>
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</table>


Costs Paid By Farmers for Delivery of Surface Water for Irrigation by Hydrologic Region

<table>
<thead>
<tr>
<th>Hydrologic Region</th>
<th>2000 Unit Cost Range ($/AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Coast</td>
<td>4 - 13</td>
</tr>
<tr>
<td>Sacramento River</td>
<td>2 - 37</td>
</tr>
<tr>
<td>San Joaquin River</td>
<td>4 - 80</td>
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<tr>
<td>Tulare Lake Region</td>
<td>15 - 118</td>
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<tr>
<td>Central Coast</td>
<td>392 - 607</td>
</tr>
<tr>
<td>South Coast</td>
<td>394 - 548</td>
</tr>
<tr>
<td>Colorado River</td>
<td>7 - 17</td>
</tr>
</tbody>
</table>

Source: Estimated unit surface costs from DWR 2000 Agricultural Water Cost Survey.
# California Water Plan Update 2005

## Urban Water Costs for Typical Single Family Households
(Selected Cities and Water Purveyors)

<table>
<thead>
<tr>
<th>Hydrologic Region</th>
<th>City</th>
<th>Fixed Charge</th>
<th>Incremental Cost ($/AF)</th>
<th>Rate Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacramento River</td>
<td>Lucerne</td>
<td>$14.30</td>
<td>$956.00</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Clearlake Park</td>
<td>$33.35</td>
<td>$1,275.00</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Redding</td>
<td>$8.18</td>
<td>$327.00</td>
<td>U</td>
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<tr>
<td></td>
<td>Marysville</td>
<td>$9.50</td>
<td>$293.00</td>
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</tr>
<tr>
<td></td>
<td>Elk Grove</td>
<td>$13.66</td>
<td>$0.00</td>
<td>F</td>
</tr>
<tr>
<td>San Joaquin River</td>
<td>Stockton</td>
<td>$8.80</td>
<td>$411.00</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Merced</td>
<td>$18.33</td>
<td>$0.00</td>
<td>F</td>
</tr>
<tr>
<td>Tulare Lake</td>
<td>Bakersfield</td>
<td>$12.00</td>
<td>$415.00</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Bakersfield</td>
<td>$40.83</td>
<td>$0.00</td>
<td>F</td>
</tr>
<tr>
<td>North Coast</td>
<td>Santa Rosa</td>
<td>$4.65</td>
<td>$864.00</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Bodega Bay</td>
<td>$15.00</td>
<td>$0.00</td>
<td>F</td>
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<td>San Francisco Bay</td>
<td>San Jose</td>
<td>$11.33</td>
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<td></td>
<td>Livermore</td>
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<td></td>
<td>South San Francisco</td>
<td>$10.62</td>
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<td>Central Coast</td>
<td>Santa Maria</td>
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<td></td>
<td>Salinas</td>
<td>$10.10</td>
<td>$371.00</td>
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<tr>
<td>South Coast</td>
<td>Ojai</td>
<td>$15.35</td>
<td>$833.00</td>
<td>IB</td>
</tr>
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<td></td>
<td>Simi Valley</td>
<td>$9.70</td>
<td>$784.00</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Long Beach</td>
<td>$13.00</td>
<td>$843.00</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Thousand Oaks</td>
<td>$10.70</td>
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<td></td>
<td>Coronado</td>
<td>$6.50</td>
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<tr>
<td>North Lahontan</td>
<td>Mammoth Lakes</td>
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<td>Truckee</td>
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<td>$690.00</td>
<td>U</td>
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<td>Victorville</td>
<td>$12.55</td>
<td>$917.00</td>
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</tr>
<tr>
<td></td>
<td>Hesperia</td>
<td>$29.28</td>
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<td>IB</td>
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<tr>
<td>Colorado River</td>
<td>Needles</td>
<td>$23.00</td>
<td>$0.00</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>Calipatria</td>
<td>$24.10</td>
<td>$483.00</td>
<td>U</td>
</tr>
</tbody>
</table>

**Note:** U = Uniform Rate, IB = Increasing Block Rate, F = Flat Rate

**Sources:** DWR computations from on-line rate information made available by individual water agencies in 2004 for uniform and increasing block rate agencies. Flat rate information from Black & Veatch 2003 *California Water Charge Survey.*
Water Allocation, Use and Regulation in California
Water Allocation, Use and Regulation in California

In California, water use and supplies are controlled and managed under an intricate system of common law principles, constitutional provisions, State and federal statutes, court decisions, and contracts or agreements. All of these components constitute the institutional framework for the protection of public interests and their balance with private claims in California’s water allocation and management.

Constitutional, Statutory and Common Law Framework for Water Uses

The people of California own all the water in the state. Water rights provide the right to reasonable and beneficial use of the water, not ownership of the water. Public interests are thus involved at every level of water management in California.

Principle of Reasonable and Beneficial Use

California’s water law and policy, Article X, Section 2 of the California Constitution, requires that all uses of the state’s water be both reasonable and beneficial. It places a significant limitation on water rights by prohibiting the waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water. However, the interpretation of what is wasteful can vary significantly depending on the circumstances and may depend on opinions of the State Water Resources Control Board or ultimately, the courts.

Public Trust Doctrine Values and Trustees

Rights to use water are subject to the State’s obligation under the Public Trust Doctrine as trustee of certain resources for Californians. The Public Trust Doctrine is a legal doctrine that imposes responsibilities on State agencies to protect trust resources associated with California’s waterways, such as navigation, fisheries, recreation, ecological preservation and related beneficial uses. In National Audubon Society v. Superior Court of Alpine County, the California Supreme Court concluded that the public trust is an affirmation of the duty of the State to protect the people’s common heritage of streams, lakes, marshlands, and tidelands, surrendering such protection only in rare cases when the abandonment of that right is consistent with the purposes of the trust. Thus, California agencies have fiduciary obligations to the public when they make decisions affecting trust assets.

CALIFORNIA CONSTITUTION
ARTICLE 10 WATER
SEC. 2. It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare. The right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water. Riparian rights in a stream or water course attach to, but to no more than so much of the flow thereof as may be required or used consistently with this section, for the purposes for which such lands are, or may be made adaptable, in view of such reasonable and beneficial uses; provided, however, that nothing herein contained shall be construed as depriving any riparian owner of the reasonable use of water of the stream to which the owner’s land is riparian under reasonable methods of diversion and use, or as depriving any appropriator of water to which the appropriator is lawfully entitled. This section shall be self-executing, and the Legislature may also enact laws in the furtherance of the policy in this section contained.
In National Audubon, the court addressed the relationship between the Public Trust Doctrine and California’s water rights system, and integrated them. The court reached three major conclusions:

• The State retains continuing supervisory control over its navigable waters and the lands beneath them. This prevents any party from acquiring a vested right to appropriate water in a manner harmful to the uses protected by the public trust. The State Water Resources Control Board may reconsider past water allocation decisions in light of current knowledge and current needs.

• As a practical matter, it will be necessary for the State to grant usufructuary licenses to allow appropriation of water for uses outside the stream, even though this taking may unavoidably harm the trust uses of the source stream.

• “The State has an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible.”

Thus, while the State may, as a matter of practical necessity, have to approve appropriations that will cause harm to trust uses, it “must at all times bear in mind its duty as trustee to consider the effect of such taking on the public trust, (cite omitted) and to preserve, so far as consistent with the public interest, the uses protected by the trust.”

Surface Water Rights
California’s system for surface water rights recognizes both riparian rights and appropriative rights. Riparian rights were adopted in California as a part of the English Common Law when California became a state in 1850. At that time, gold miners were already operating under their own system that recognized claims to water rights based on prior appropriation.

Riparian
A riparian right is the right to divert, but not store, a portion of the natural flow for use based on the ownership of property adjacent to a natural watercourse. Water claimed through a riparian right must be used on the riparian parcel. Such a right is generally attached to the riparian parcel of land except where a riparian right has been preserved for non-contiguous parcels when land is subdivided. Generally, riparian rights are not lost through non-use. All riparian water users have the same priority; senior and junior riparian water rights do not exist. During times of water shortage, all riparian water users must adjust their water use to allow equal sharing of the available water supply.

Appropriative
Under the prior appropriation doctrine, a person may acquire a right to divert, store, and use water regardless of whether the land on which it is used is adjacent to a stream or within its watershed. The rule of priority between appropriators is "first in time is first in right." A senior appropriative water rights holder may not change an established use of the water to the detriment of a junior, including a junior’s reliance on a senior’s return flow. Acquisition of appropriative water rights is subject to the issuance of a permit by the State Water Resources Control Board (SWRCB) with priority based on the date a permit is issued. Permit and license provisions do not apply to pre-1914 appropriative rights (those initiated before the Water Commission Act took effect in 1914), but pre-1914 rights are still subject to reasonable and beneficial use. Appropriative rights may be sold or transferred.

Groundwater Use and Management
With the exception of the 19 adjudicated groundwater basins and basins in which a local agency has obtained statutory authority to manage groundwater, any overlying landowner in California has the right to build a well and extract groundwater as long as that groundwater is put to a reasonable and beneficial
use. In 1903, the California Supreme Court rejected the English Common Law system of absolute ownership of groundwater, which allowed for unregulated pumping of groundwater. Instead, the court adopted the rule of "reasonable use of percolating waters." This established the doctrine of "correlative rights and reasonable use" under which every landowner in the basin has a right to extract and use groundwater and that right is correlative with the rights of all the overlying landowners in the basin. Those correlative rights are not quantified until the basin is adjudicated. An overlying landowner’s right is considered to be analogous to a riparian right to surface water. Groundwater can be appropriated by taking the water for use on non-overlying lands if water is surplus to the reasonable needs of overlying owners.

California does not have a statewide management program or permit system to regulate the extraction and appropriation of groundwater. Courts have recognized that groundwater management is the responsibility of local agencies. In addition to the 19 adjudicated basins in which groundwater extraction is regulated by the watermaster appointed by State or federal courts, some local agencies have obtained statutory authority from the Legislature to manage groundwater within their agency’s boundaries. Statutory management may be granted to a public agency that also manages surface water, or to a groundwater management agency created expressly for that purpose by a special district act. There are nine such special districts, but most have not successfully developed groundwater management plans. Several other local agencies have obtained statutory authority to manage groundwater by returning to the Legislature and requesting amendments to the Water Code to allow them to manage groundwater. Only a few of these agencies have enacted a groundwater replenishment fee, a groundwater extraction fee, or a recharge fee, all of which are colloquially called a "pump tax." Water resources are specifically referenced in general plan statutes and mandate close coordination of land use and water supply agencies. More recently, some counties have enacted ordinances that are aimed primarily at protecting groundwater resources within their county.

In 1991, the Water Code was amended by Assembly Bill 255 to allow local water agencies overlying critically overdrafted groundwater basins to develop groundwater management plans. Seven local agencies adopted plans pursuant to that authorization. In 1992, the Water Code was again amended by AB 3030, which authorized water agencies in any groundwater basin to develop a groundwater management plan, if the groundwater was not subject to management under other provisions of law or a court decree. Plans adopted pursuant to the 1992 statute may include, but are not limited to, 12 technical components including control of salt water intrusion; identification and protection of wellhead and recharge areas; regulation of the migration of contaminated water; provisions for abandonment and destruction of wells; mitigation of overdraft; replenishment; monitoring; facilitating conjunctive use; identification of well construction policies; and construction of cleanup, recharge, recycling, and extraction projects by the local agency. About 190 agencies have adopted groundwater management plans in accordance with AB 3030.

The same part of the Water Code (section 10750 et seq.) was amended again in 2002 by SB 1938 and now requires that five specific components must be included in a groundwater management plan if the agency applies for State funding made available after September 1, 2002. Even if an agency does not apply for State funding, however, the Legislature’s intent was to provide standards for groundwater management by prudent groundwater managers. Applicant agencies for funding authorized by AB 303 (Thomson, Chapter 708, Statutes of 2000) are specifically excluded from the required components in that such funding was intended by the Legislature to enable under funded local agencies to begin a
groundwater management program. Again, however, a prudent manager would strive to meet minimum standards.

**Tribal Water Rights**

Some Indian reservations and other federal lands have reserved water rights implied from acts of the federal government, rather than state law. When tribal lands were reserved, their natural resources were also reserved for tribal use. Since reserved tribal rights were generally not created by state law, states' water allocations did not account for tribal resources. In the landmark Winters v. U.S. case, in 1908 the U.S. Supreme Court established that sufficient water was reserved to fulfill the uses of a reservation at the time the reservation was established. The decision, however, did not indicate a method for quantifying tribal water rights. Winters rights also retain their validity and seniority over state appropriated water whether or not the tribes have put the water to beneficial use. Only after many years did tribes begin to assert and develop their reserved water rights. In 1963, the U.S. Supreme Court decision Arizona v. California reaffirmed Winters and established a quantification standard based on irrigation, presupposing that tribes would pursue agriculture. Despite criticisms of the "practically irrigable acreage" (PIA) quantification standard from various perspectives, the PIA standard provided certainty to future water development. Quantifying water needs in terms of agricultural potential does not accurately show the many other needs for water. Even urban water quantity and quality assessments that look at the adequacy of the domestic water supply and sanitation do not provide a complete picture of tribal water needs. A large part of the tribal water needs are for instream flows and other water bodies that support environmental and cultural needs for fishing, hunting, and trapping.

The 1902 Reclamation Act promulgated the establishment of irrigated agriculture and settlement throughout the Western states. Historical perspective indicates this policy was pursued generally without regard to Indian water rights or the 1908 Winters decision. In 1952, Congress passed the McCarran Amendment allowing the federal government to waive sovereign immunity and participate in state general stream adjudications. The Court later ruled that state adjudications may also apply to Indian reserved water rights held in trust by the United States. In asserting their Winters rights, tribes have come into conflict with water-using development that grew out of substantial federal and private investment. Costly litigation, negotiation, or combinations thereof are the usual means of resolving Indian water disputes, and some cases can take decades to reach agreement. Some tribes request assistance from the federal government to pursue their water rights settlements, reminding concerned parties of the conflicting roles the federal government can assume on two or more sides of a judicial or administrative issue.

**The Law of the River**

The Colorado River is managed and operated under numerous compacts, federal laws, court decisions and decrees, contracts, and regulatory guidelines collectively known as the "Law of the River." In 1922, the seven Colorado River basin states negotiated the Colorado River Compact, which divided the states into two basins—upper and lower—and apportioned 7.5 million acre-feet per year to each basin. The compact also referenced Mexico's right to the Colorado. The Boulder Canyon Project Act of 1928 ratified the Compact and established California’s apportionment at 4.4 maf/year. In 1944, the United States signed a water treaty in which it agreed to deliver 1.5 million acre-feet of water annually to Mexico.
While compact negotiators estimated the flow of the river to be at least 17 million acre-feet per year, today's records indicate a flow of 15 million at Lee Ferry, just below Lake Powell. Consequently, the sum of the actual compact apportionments and the Mexican treaty exceed the flow of the river in most years.

**Water Contracts**
Both the State Water Project and Central Valley Project have contracts to deliver water to water agencies:

**State Water Project**
DWR has long-term water supply contracts for water service from the State Water Project with 29 local agencies from Plumas County Flood Control and Water Conservation District in the north to the Metropolitan Water District of Southern California in the south. In return for State financing, constructing, operating, and maintaining facilities needed to provide water service, the agencies contractually agreed to repay all associated SWP capital and operating costs. The Annual Table A represents the total amount of project water that a SWP contractor may request each year, according to that contractor’s long-term water supply contract. Depending on hydrologic conditions, the actual delivery may be different than the requested amount. Most of the SWP water goes to urban uses. As a result of amendments to contracts in the 1990s, the current combined maximum annual Table A amount totals 4,172,786 acre-feet for all 29 contractors. The contracts are in effect for the longest of the following periods: (1) the project repayment period, which extends to the year 2035; (2) 75 years from the date of the contract; or (3) the period ending with the latest maturity date of any bond used to finance the construction costs of project facilities.

**Central Valley Project**
The CVP supplies water to more than 250 long-term water contractors extending from Shasta County in the north to Kern County in the south. Most CVP water goes to agricultural uses. Collectively, the contracts call for a maximum annual delivery of 9.3 MAF; 4.8 MAF is classified as project water and 4.5 MAF is classified as water right settlement water. Contractors that receive project water repay project capital and operation and maintenance costs. Water right settlement water is water covered in agreements with water rights holders whose diversions existed before the project was constructed. Project operations altered natural river flow upon which these pre-project diverters had relied, so contracts were negotiated to agree on the quantities of diversions that could be made without any payment to the United States. Water rights settlement contractors on the upper Sacramento River receive their supply from natural flow and storage regulated at Shasta Dam. Settlement contractors on the San Joaquin River (called exchange contractors) receive Delta water diverted from the Delta and stored in San Luis Reservoir and/or pumped directly via the Delta-Mendota Canal.

**Releases of Water for Environmental Uses**
Fish and Game Code Section 5937 provides protection to fisheries by requiring that the owner of any dam allow sufficient water to pass downstream to keep in good condition any fisheries that may be planted or exist below the dam. See the adjoining page for other resource management regulations. See the adjoining page for other environmental regulations.

**Water Transfers**
Every year, hundreds of water transfers take place between water users within water districts. These districts have their own rules for the initial allocation of water to their users. Water transfers between water districts within the same water basin are becoming more common. Local rules allow districts to transfer water through groundwater banking agreements or other joint water development projects. In many cases, local rules provide members the right of first refusal to obtain the water before the water is
transferred to outside parties. Emergency water transfers are generally exempt from California Environmental Quality Act review.

In 1995 and 1996, the SWP negotiated a set of principles (Monterey Agreement), which among other things, changed the operating rules of the SWP to allow banking and limited water transfers among SWP users. Based on these principles and a final EIR, 27 of the 29 SWP contractors executed the amendment (Monterey Amendment) to their contracts. Based on challenges to the EIR, DWR is preparing a new EIR for the Monterey Amendment.

The Central Valley Project Improvement Act authorized transfer of project water outside the CVP service area, subject to many conditions, including a right of first refusal by entities within the service area. Transfers must be consistent with State law, be approved by USBR, and be approved by the contracting water district if the transfer involves more than 20 percent of its long-term contract supply. USBR has published interim guidelines for administration of this provision, pending formal promulgation of rules and regulations.

In the mid-1980s and 1990s, the Legislature passed several laws making it easier to transfer water beyond the boundaries of historical water service areas. These laws are aimed at protecting water users who are not a party to the transfer and fish and wildlife from being injured or unreasonably affected by the transfer. These laws developed an expedited process for the SWRCB to expand the water rights of those conducting a short-term (one year) water transfer. The process requires SWRCB to make findings within 45 days. Once the findings are made, the water right is modified to allow the water right holder to serve, on a temporary basis, additional places of use or to use alternative points of diversion. The receiving party gets the use of the water, but does not obtain any rights to the water; the water rights are maintained by the original water right holder.

CALS included actions to facilitate water transfers. The ON TAP website provides information and disclosure of water market information resources for water users. (See http://ontap.ca.gov).

DWR purchases water for the newly created Environmental Water Account and the Dry Year Program for California. DWR has made it clear in recent water transfer papers that it only will be involved in the purchase of water from willing sellers who include in their proposals monitoring and mitigation programs that resolve possible impacts to other water users and fish and wildlife; see www.watertransfers.water.ca.gov. DWR has evaluated its role as a water purchaser in light of the legislative guidance provided in the Water Code regarding water transfers. Through this evaluation DWR has defined the nature of the water it wishes to purchase in much the same way that any consumer in the marketplace decides the nature of the products to be purchased. These definitions are seen as a step toward creating a more equitable water market that addresses early in the process the impacts to third parties. These same issues and the development of mechanisms to resolve them are part of a settlement process between northern California water users, the CVP, and the SWP regarding the role northern California should play in making water available to assist in meeting water quality standards in the Delta.

Area of Origin Protections
During the years when California's two largest water projects, the CVP and SWP, were being planned and developed, area of origin provisions were added to the water code to protect local Northern California supplies from being depleted by the projects. County of origin statutes reserve water supplies for counties

Background
in which the water originates when, in the judgment of the SWRCB, an application for the assignment or release from priority of State water right filings will deprive the county of water necessary for its present and future development. Watershed protection statutes are provisions that require that the CVP and the SWP not deprive those in a watershed from the future beneficial water needs.

The Delta Protection Act, enacted in 1959 (not to be confused with the Delta Protection Act of 1992), declares that the maintenance of an adequate water supply in the Delta to maintain and expand agriculture, industry, urban, and recreational development in the Delta area and provide a common source of fresh water for export to areas of water deficiency is necessary for the peace, health, safety, and welfare of the people of the State, and is subject to the County of Origin and Watershed Protection laws. The act requires the SWP and the CVP to provide salinity control in the Delta and an adequate water supply for water users in the Delta.

In 1984, additional area of origin protections were enacted covering the Sacramento, Mokelumne, Calaveras, and San Joaquin Rivers; the combined Truckee, Carson, and Walker Rivers; and Mono Lake. The protections prohibit the export of groundwater from the combined Sacramento River and Delta Basins, unless the export is in compliance with local groundwater plans.

**Regulations Protecting Water Quality**

Water quality is an important aspect of water resource management. Discussed below are the key State and federal laws governing water quality.

**Clean Water Act-National Pollutant Discharge Elimination System**

Section 402 of the Clean Water Act established a permit system known as the National Pollutant Discharge Elimination System (NPDES) to regulate point sources of discharges in navigable waters of the United States. The EPA was given the authority to implement the NPDES, although the Act also authorizes states to implement the NPDES program in lieu of the EPA, provided the state has sufficient authority.

After the Clean Water Act was enacted in 1972, U.S. EPA and the states focused primarily on implementing technology-based controls for “point” sources (for example, discharges from pipes from factories and municipal sewage treatment plants). Today, those controls are largely in place, and the focus is beginning to shift to “non-point source” pollution, such as runoff from cities and farms.

**Porter-Cologne Water Quality Control Act**

This Act is California's comprehensive water quality control law and is a complete regulatory program designed to protect water quality and beneficial uses of the State's water.

The Act requires the adoption of water quality control plans by the State's nine Regional Water Quality Control Boards for watersheds within their regions. These plans are nominally reviewed and updated triennially, and their adoption is subject to the approval of the SWRCB and ultimately the federal EPA. Moreover, pursuant to Porter-Cologne, these basin plans shall become part of the California Water Plan Update 2005, when such plans have been reported to the Legislature (Section 13141, California Water Code).
In 1972, the Legislature amended the Porter-Cologne Act to give California the authority and ability to operate the federal NPDES permits program. Before a permit may be issued, Section 401 of the Clean Water Act requires that the RWQCB certify that the discharge will comply with applicable water quality standards. In addition, under Porter-Cologne, the RWQCB may also issue waste discharge requirements, that set conditions on the discharge of a waste. These requirements must be consistent with the water quality control plan for the body of water that receives the waste discharge, as well as protect the beneficial uses of those receiving waters.

The regional boards also implement Section 402 of the federal Clean Water Act, which allows the State to issue a single discharge permit for stormwater runoff for the purposes of both State and federal law.

**Safe Drinking Water Act**

The Safe Drinking Water Act (SDWA), enacted in 1974 and significantly amended in 1986 and 1996, directed the EPA to set national standards for drinking water quality. It required the EPA to set maximum contaminant levels for a wide variety of constituents. Local water suppliers are required to monitor their water supplies to assure that regulatory standards are not exceeded.

The Maximum Contaminant Level (MCL) is the maximum concentration of a contaminant that is allowed in public drinking water systems. The 1986 amendments set a timetable for the EPA to establish standards for specific contaminants and increased the range of contaminants local water suppliers were required to monitor to include contaminants that did not yet have an MCL established. The 1986 Safe Drinking Water Act Amendments also led to the EPA’s adoption of the Surface Water Treatment Rule, which addresses filtration and disinfection of surface waters. The amendments included a wellhead protection program, a grant program for designating sole-source aquifers for special protection, and grant programs and technical and financial assistance to small systems and states.

The 1996 amendments included stronger regulation of microbial contaminants (i.e. Cryptosporidium) while managing levels of disinfection byproducts, source water assessment programs, and establishment of a drinking water state revolving fund. The source water assessment and protection programs offer tools and opportunities to build a prevention barrier to drinking water contamination. Under SDWA, the State is required to develop comprehensive Source Water Assessment Programs that will identify the areas that supply public tap water, inventory contaminants and assess water system susceptibility to contamination, and inform the public of the results.

For every new standard, EPA conducts an analysis to determine if the benefits of the standard justify the costs. If not, EPA may adjust the MCL to a level that “maximizes the health risk reduction benefits at a cost that is justified by the benefits.”

**California Safe Drinking Water Act**

In 1976, California enacted its own Safe Drinking Water Act, requiring DHS to regulate drinking water, including: setting and enforcing federal and State drinking water standards; administering water quality testing programs; and administering permits for public water system operations. In 1989, significant amendments to the California act incorporated the new federal safe drinking water act requirements into California law, gave DHS discretion to set more stringent MCLs, and recommended public health levels for contaminants.
Environmental Laws for Protecting Resources

Several laws outline the State and federal obligations to protect and restore degraded habitats and species.

Protecting Endangered Species and Habitats

Federal Endangered Species Act
Under the federal ESA, an endangered species is one that is in danger of extinction in all or a significant part of its range, and a threatened species is one that is likely to become endangered in the near future. The ESA is designed to preserve endangered and threatened species by protecting individuals of the species and their habitat and by implementing measures that promote their recovery. The ESA sets forth a procedure for listing species as threatened or endangered. Final listing decisions are made by USFWS or NMFS.

Once a species is listed, Section 7 of the act requires that federal agencies, in consultation with the USFWS or NMFS, ensure that their actions do not jeopardize the continued existence of the species or habitat critical for the survival of that species. The federal wildlife agencies are required to provide an opinion as to whether the federal action would jeopardize the species. The opinion must include reasonable and prudent alternatives to the action that would avoid jeopardizing the species' existence. Federal actions subject to Section 7 include issuance of federal permits such as the dredge and fill permit required under Section 404 of the federal Clean Water Act, which requires that the project proponent demonstrate that there is no feasible alternative consistent with the project goals that would not affect listed species. Mitigation of the proposed project is not considered until this hurdle is passed.

State agencies and private parties also are subject to the ESA. Section 9 of the ESA prohibits the "take" of endangered species and threatened species for which protective regulations have been adopted. Take has been broadly defined to include actions that harm or harass listed species or that cause a significant loss of their habitat. State agencies and private parties are generally required to obtain a permit from the USFWS or NMFS under Section 10(a) of the ESA before carrying out activities that may incidentally result in taking listed species. The permit normally contains conditions to avoid taking listed species and to compensate for habitat adversely impacted by the activities.

California Endangered Species Act
The California Endangered Species Act is similar to the federal ESA. Listing decisions are made by the California Fish and Game Commission. All State lead agencies are required to consult with the Department of Fish and Game about projects that impact State listed species. DFG is required to render an opinion as to whether the proposed project jeopardizes a listed species and to offer alternatives to avoid jeopardy. State agencies must adopt reasonable alternatives unless there are overriding social or economic conditions that make such alternatives infeasible. For projects causing incidental take, DFG is required to specify reasonable and prudent measures to minimize take. Any take that results from activities that are carried out in compliance with these measures is not prohibited.

Many California species are both federally listed and State listed. CESA directs DFG to coordinate with the USFWS and NMFS in the consultation process so that consistent and compatible opinions or findings can be adopted by both federal and State agencies.
Natural Community Conservation Planning
Adopted in 1991, California's Natural Community Conservation Planning Act establishes a program to identify the habitat needs of species before they become listed as threatened or endangered, and to develop appropriate voluntary conservation methods compatible with development and growth. Participants in the program develop plans to protect certain habitat and will ultimately enter into agreements with DFG to ensure that the plans will be carried out. Plans must be created so that they are consistent with endangered species laws.

Dredge and Fill Permits
Section 404 of the federal Clean Water Act regulates the discharge of dredged and fill materials into waters of the United States, including wetlands. The term "discharge of dredged and fill material" has been defined broadly to include the construction of any structure involving rock, soil, or other construction material. No discharge may occur unless a permit is obtained from the U.S. Army Corps of Engineers (USACE). Generally, the project proponent must agree to mitigate or have plans to mitigate environmental impacts caused by the project before a permit is issued. The EPA has the authority to veto permits issued by the USACE for projects that have unacceptable adverse effects on municipal water supplies, fisheries, wildlife, or recreation areas.

Section 404 allows the issuance of a general permit on a state, regional, or nationwide basis for certain categories of activities that will cause only minimal environmental effects. Such activities are permitted without the need of an individual permit application. Installation of a stream gaging station along a river levee is one example of an activity that falls within a nationwide permit.

The USACE also administers a permitting program under Section 10 of the 1899 Rivers and Harbors Act. Section 10 generally requires a permit for obstructions to navigable water. The scope of the permit under Section 10 is narrower than under Section 404 since the term "navigable waters" is more limited than "waters of the United States."

Most water development projects must comply with Section 404, Section 10, or both.

Public Interest Terms and Conditions
The Water Code authorizes the SWRCB to impose public interest terms and conditions to conserve the public interest, specifically the consideration of instream beneficial uses, when it issues permits to appropriate water.

Local General Plans and Specific Plans
Local (city and county) general plans and specific plans provide methods to manage and protect fish and wildlife. The conservation element of a plan provides direction and objectives for the conservation, development and use of natural resources. The open-space element of a plan guides the comprehensive, long-range preservation and conservation of open space lands including water bodies.

Releases of Water for Fish
Fish and Game Code Section 5937 provides protection to fisheries by requiring that the owner of any dam allow sufficient water at all times to pass through the dam to keep in good condition any fisheries that may be planted or exist below the dam. In California Trout, Inc. v. the State Water Resources Control Board (1989), the court determined that Fish and Game Code sections 5937 and 5946 required the SWRCB to modify the permits and licenses issued to the City of Los Angeles to appropriate water from the streams feeding Mono Lake to ensure sufficient water flows for downstream fisheries. The SWRCB reconsidered Los Angeles' permits and licenses in light of Fish and Game Code Section 5937 and the
public trust doctrine. In 1994, the SWRCB adopted D-1631, which requires Los Angeles to allow sufficient flows from the streams feeding Mono Lake to reach the lake to allow it to rise to the level of 6,391 feet in approximately 20 years.

**Streambed Alteration Agreements**
Fish and Game Code Sections 1601 and 1603 require that any governmental entity or private party altering a river, stream, lakebed, bottom, or channel enter into an agreement with DFG. When the project may substantially impact an existing fish or wildlife resource, DFG may require that the agreement include provisions designed to protect riparian habitat, fisheries, and wildlife. New water development projects and ongoing maintenance activities are often subject to these sections.

**Migratory Bird Treaty Act**
This act implements various treaties for the protection of migratory birds and prohibits the "taking" (broadly defined) of birds protected by those treaties without a permit. The Secretary of the Interior determines conditions under which a taking may occur, and criminal penalties are provided for unlawfully taking or transporting protected birds. Liability imposed by this act was one of several factors leading to the decision to close the San Luis Drain and Kesterson Reservoir.

**Fish and Wildlife Coordination Act**
The Fish and Wildlife Coordination Act expresses congressional policy to protect the quality of the aquatic environment as it affects the conservation, improvement, and enjoyment of fish and wildlife resources. Under this act, any federal agency that proposes to control or modify any body of water, or to issue a permit allowing control or modification of a body of water, must first consult with the USFWS and state wildlife officials. This requires coordination early in the project planning and environmental review processes.

**CVPIA**
In 1992, the Central Valley Project Improvement Act (Title 34 of PL 102-575) made significant changes to the CVP's legislative authorization, amending the project's purposes to place fish and wildlife mitigation and restoration on a par with water supply, and to place fish and wildlife enhancement on a par with power generation.
**Major Provisions of CVPIA (1992)**

- No new CVP water supply contracts for purposes other than fish and wildlife (with a few limited exceptions) until all environmental restoration actions specified in the act have been completed.
- Allows transfers of project water to users outside of the CVP service area, under numerous specified conditions including a right of first refusal to a proposed transfer by existing CVP water users (under the same terms and conditions specified in the proposed transfer), and a requirement that proposed transfers of more than 20 percent of a contracting agency’s project water supply be subject to review and approval by the contracting agency.
- Requires Department of Interior to develop water conservation criteria, and to review conservation plans submitted by contracting agencies pursuant to Reclamation Reform Act requirements for conformance to the CVPIA criteria. Tiered pricing is to be included in CVP water supply contracts when they are renewed. Project water supply and repayment contractors' surface water delivery systems are to be equipped with water measurement devices.
- All reasonable efforts to double, by 2002, natural production (based on 1967-91 fishery population levels) of specified anadromous fish in the Central Valley, and to implement that program. A portion of the San Joaquin River is exempted from this provision.
- Dedication of 800 taf/yr of CVP yield to fish and wildlife purposes, and acquisition of supplemental water for meeting the fish doubling goal.
- An annual Trinity River instream flow of at least 340 taf through 1996, via releases from Lewiston Dam, with subsequent instream flow requirements to be determined by a USFWS instream flow study.
- Deliver water corresponding to existing non-firm supplies to specified federal, State, and private wildlife refuges in the Sacramento and San Joaquin Valleys. DOI is to acquire, from willing sellers, an additional increment of water supply for the wildlife areas, corresponding to their full habitat development needs. All of the supplemental water needs are to be met by 2002.
- Implementation of numerous specified environmental restoration actions, such as remedying fish passage problems at Red Bluff Diversion Dam, replenishing spawning gravel, and assisting in screening non-federal diversions.
- Preparation of specified reports and studies including a least-cost plan to replace the 800 taf/yr of project yield dedicated to environmental purposes, and an evaluation of water supply and development requirements for 120,000 acres of wetlands identified in a Central Valley Habitat Joint Venture report.
- A land retirement program, and specifies categories of land that may be acquired. San Joaquin Valley drainage-impaired lands are among the authorized categories.
- CVPIA restoration fund within the federal treasury to collect mitigation and restoration payments from project water and power users.
Water Allocation, Use and Regulation in California

Several statutes designed to set aside resources or areas to preserve their natural conditions for habitat, watershed protection, recreational, and scenic values also affect water use and management. These statutes preclude many activities, including most water development projects, within the areas set aside.

State and Federal Wild and Scenic Rivers System

In 1968, Congress passed the National Wild and Scenic Rivers Act to preserve, in their free flowing condition, rivers which possess "outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values." The act also states "... that the established national policy of dam and other construction at appropriate sections of rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes."

The act prohibits federal agencies from constructing, authorizing, or funding the construction of water resources projects having a direct and adverse effect on the values for which a river was designated. This restriction also applies to rivers designated for potential addition to the National Wild and Scenic Rivers System. Included in the system are most rivers protected under California's State Wild and Scenic Rivers Act; these rivers were included in the national system upon California's petition on January 19, 1981. The West Walker and East Fork Carson Rivers are not included in the federal system.

In 1972, the Legislature passed the California Wild and Scenic Rivers Act, declaring that specified rivers possess extraordinary scenic, recreational, fishery, or wildlife values, and should be preserved in a free flowing state for the benefit of the people of California. The Act declared that such use of the rivers would be the highest and most beneficial use within the meaning of Article X, Section 2 of the California Constitution. The act prohibits construction of any dam, reservoir, diversion, or other water impoundment on a designated river. Diversions needed to supply domestic water to residents of counties through which the river flows may be authorized, if the Secretary for Resources determines that the diversion will not adversely affect the river's free-flowing character. The major difference between the national and State acts is that if a river is designated wild and scenic under the State act, the Federal Energy Regulatory Commission (FERC) can still issue a license to build a dam on that river, thus overriding the State system. (See Federal Power Act later in this chapter.) This difference explains why national wild and scenic designation is often sought.

National Wilderness Act

The Wilderness Act sets up a system to protect federal land designated by Congress as a "wilderness area" and preserve it in its natural condition. Wilderness is defined as undeveloped federal land retaining its primeval character and influence without permanent improvements or human habitation. Commercial enterprise, permanent roads, motor vehicles, aircraft landings, motorized equipment, or construction of structures or installations (such as dams, diversions, conveyance facilities, and gaging stations) are prohibited within designated wilderness areas.

Watershed Management and Protection Practices

Many State and federal agencies have authority for managing and protecting watershed areas including the State Parks and Recreation system, national forest service lands, public lands administered by the Bureau of Land Management, and the national park system. Cities and counties serve as local land management agencies that often coordinate and provide an institutional focus for watershed efforts. In
addition, local resource conservation districts and watershed groups assume active roles in management and protection for many watersheds.

Regulating Project Planning, Implementation and Mitigation

Another set of environmental statutes compels governmental agencies and private individuals to document and consider the environmental consequences of their actions. The statutes define the procedures through which governmental agencies must consider environmental factors in their decision-making process.

National Environmental Policy Act

NEPA directs federal agencies to prepare an environmental impact statement (EIS) for all major federal actions that may have a significant effect on the human environment. It states that it is the goal of the federal government to use all practicable means, consistent with other considerations of national policy, to protect and enhance the quality of the environment. It is a procedural law requiring all federal agencies to consider the environmental impacts of their proposed actions during the planning and decision-making processes.

NEPA requires preparation of an EIS to document a major Federal action that could significantly affect the quality of the human environment. An EIS includes the environmental impact of the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, alternatives to the proposed action, the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. NEPA does not generally require federal agencies to adopt mitigation measures or alternatives provided in the EIS.

California Environmental Quality Act

CEQA, modeled after NEPA, requires California public agency decision-makers to document and consider the environmental impacts of their actions. It requires an agency to identify ways to avoid or reduce environmental damage, and to implement those measures where feasible. CEQA applies to all levels of California government, including the State, counties, cities, and local districts.

CEQA requires that a public agency carrying out a project with significant environmental effects prepare an environmental impact report (EIR). An EIR contains a description of the project; a discussion of the project's environmental impacts, mitigation measures, and alternatives; public comments; and the agency's responses to the comments. In other instances, a notice of exemption from the application of CEQA may also be appropriate.

CEQA imposes substantive duties on all California governmental agencies that approve projects with significant environmental impacts to adopt feasible alternatives or mitigation measures that substantially lessen these impacts, unless there are overriding reasons. When a project is subject to both CEQA and NEPA, both laws encourage the State and federal agencies to cooperate in planning the project and to prepare joint environmental documents.
Regulations for Water Use Efficiency

Article X, Section 2 of the California Constitution prohibits the waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water. It also declares that the conservation and use of water "shall be exercised with a view to the reasonable and beneficial use thereof in the public interest and for the public welfare." Although provisions and requirements of the Constitution are self-executing, the Constitution states that the Legislature may enact statutes to advance its policy. Water Code Section 275 directs the Department and SWRCB to "take all appropriate proceedings or actions before executive, legislative, or judicial agencies to prevent waste or unreasonable use of water." SWRCB's Water Right Decision 1600, directing the Imperial Irrigation District to adopt a water conservation plan, is an example of an action brought under Article X, Section 2. SWRCB's authority to order preparation of such a plan was upheld in 1990 by the courts in Imperial Irrigation District v. State Water Resources Control Board. Other complaints have been pending before the Board for years including some which pose the question of whether continued irrigation of soils known to contain toxic concentrations of selenium and other contaminants constitute either reasonable or beneficial use when measured against their known impacts.

Urban Water Management Planning Act
Since 1983, this act has required urban water suppliers that serve more than 3,000 customers or more than 3,000 af/yr to prepare and adopt urban water conservation plans. The act authorizes the supplier to implement the water conservation program. The plans must contain several specified elements, including estimates of water use, identification of existing conservation measures, identification of alternative conservation measures, a schedule of implementation of actions proposed by the plan, and identification of the frequency and magnitude of water shortages. In 1991, the act was amended in response to the drought to require water suppliers to estimate water supplies available at the end of one, two, and three years, and to develop contingency plans for severe shortages. The act also requires water suppliers to review and update their plans at least once every five years. New requirements for urban water management plans are periodically passed by the State Legislature (see SB 610, SB 672, and SB 1518 in Section 2.6.9).

Water Conservation in Landscaping Act
The Water Conservation in Landscaping Act required DWR, with the assistance of an advisory task force, to adopt a model water-efficient landscape ordinance. The model ordinance was adopted in August 1992, and has been codified in Title 23 of the California Code of Regulations. It establishes methods of conserving water through water budgeting plans, plant use, efficient irrigation, and auditing.

Cities and counties were required to review the model ordinance and adopt a water-efficient landscape ordinance by January 1, 1993, if they had not done so already. Alternatively, cities and counties could make a finding that such an ordinance is unnecessary due to climatic, geological, or topographic conditions, or water availability. If a city or county failed to adopt a water efficient landscape ordinance or make findings by January 31, 1993, the model ordinance became effective in that jurisdiction.

Agricultural Water Management Planning Act
Under this act, agricultural water suppliers supplying more than 50 taf of water annually were required to submit a report to DWR indicating whether a significant opportunity exists to conserve water or reduce the quantity of highly saline or toxic drainage water through improved irrigation water management. The
act provided that agricultural water suppliers who indicated that they had an opportunity to conserve water or reduce the quantity of highly saline or toxic water should prepare a water management plan and submit it to the DWR.

**Agricultural Water Suppliers Efficient Management Practices Act**

The Agricultural Water Suppliers Efficient Management Practices Act, adopted in 1990, required that DWR establish an advisory committee to review efficient agricultural water management practices. Under the act, DWR was required to offer assistance to agricultural water suppliers seeking to improve the efficiency of their water management practices. The committee developed a Memorandum of Understanding to implement the practices, and to establish an Agricultural Water Management Council. The advisory committee adopted the MOU in October 1996. The MOU was declared in effect in May 1997 after 15 agricultural water suppliers, representing 2 million irrigated acres, had signed. The Council was established and held its first meeting in July 1997. The Council consists of members of the agricultural and environmental communities and other interested parties with the expressed goal for water suppliers to voluntarily develop Water Management Plans and implement Efficient Water Management Practices (EWMPs) to further advance water use efficiency while maintaining and enhancing economic, environmental and social viability and sustainability of soil and crop production.


This act gives any public agency that supplies water for agricultural use authority to institute water conservation or efficient management programs. The programs can include irrigation management services, providing information about crop water use, providing irrigation consulting services, improving the supplier's delivery system, providing technical and financial assistance to farmers, encouraging conservation through pricing of water, and monitoring.

**Water Recycling Act of 1991**

This act describes the environmental benefits and public safety of using recycled water as a reliable and cost-effective method of helping to meet California's water supply needs. It sets a statewide goal to recycle 700 taf/yr by the year 2000 and 1 maf/yr by 2010.

**CALFED Water Use Efficiency Program**

CALFED's Water Use Efficiency Program encourages investments in water use efficiency primarily through its competitive grant/loan program.

**Other Regulations**

Federal Power Act. The Federal Power Act created a federal licensing system administered by the Federal Energy Regulatory Commission and required that a license be obtained for nonfederal hydroelectric projects proposing to use navigable waters or federal lands. The act contains a clause modeled after a clause in the Reclamation Act of 1902, which disclaims any intent to affect state water rights law. In a number of decisions dating back to the 1940s, the U.S. Supreme Court has attempted to interpret the clause. In some cases they have upheld states rights and in others have held that federal law prevents any state regulation of federally licensed power projects other than determining proprietary water rights. Most recently, in 1994, the U.S. Supreme Court issued a decision referred to as the Elkhorn decision or Tacoma decision (PUD No. 1 of Jefferson County and City of Tacoma v. Washington Department of Ecology) that upheld the state’s minimum instream flow requirement as a permissible condition of a Clean Water Act Section 401 certification.
What’s So Special About Special Districts?
By Kimia Mizany and April Manatt, California Senate Local Government Committee
WHAT'S SO SPECIAL ABOUT SPECIAL DISTRICTS?
A Citizen's Guide to Special Districts in California
Third Edition

Kimia Mizany & April Manatt
February 2002
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INTRODUCTION TO THE THIRD EDITION

Most Californians don't understand special districts. Most of us don't know:

- How many exist (about 3,400).
- What they do (services from A to Z: airports to zoos).
- Who runs them (it could be your next-door neighbor).
- Or even what they cost (about $26 billion a year).

Celebrated as the best example of democracy, cursed as the worst form of fragmented government, and generally misunderstood even by the experts, special districts are California's unique contribution to local government. But what is so special about special districts anyway? The answer: focused service.

Focused because special districts only serve in specifically defined areas, unlike counties and cities that provide services throughout their boundaries. Special districts are also focused because most of them provide only a single service, allowing them to concentrate on one activity. Service because special districts deliver public programs and public facilities that their constituents want. Cities and counties must provide a wide variety of services, some of them mandated by the federal and state governments. Special districts provide the public services that the public wants.

This third edition of this citizen's guide to special districts answers many of your questions about California's most abundant form of local government. In plain language, this guide explains what special districts are, where districts came from, their legal powers, and different ways to understand them. This guide also tells you where to get more information about the special districts that serve you --- and how to form new districts in your community.

The Senate Local Government Committee first published What's So Special About Special Districts? in June 1991, the result of a research project by Senate Fellow April Manatt. In 1993, working as a Committee Consultant, Manatt produced a Second Edition. The publication has been the most popular of the Committee’s citizens guides, selling hundreds of copies. Frequently cited by other authors, this report has become a standard introduction to special district government.

But much has changed since 1993. The Legislature shifted billions of dollars of property tax revenues away from local agencies, including the districts. The voters passed more initiatives, including Proposition 218 (1996). And the California economy went through a major recession and an expansion. This Third Edition documents special districts' current financial status, revisits what is and what is not a special district, explains how many services districts provide, and describes how citizens can effect changes in the districts which serve them. Revised by Senate Fellow Kimia Mizany, the Third Edition builds on the earlier explanations.

Democracy works best when people are informed about the governments that are created to serve them. This guide will make you smarter about the special districts that serve you.
WHAT'S A SPECIAL DISTRICT?

State law defines a special district as "any agency of the state for the local performance of governmental or proprietary functions within limited boundaries" (Government Code §16271 [d]). In plain language, a special district is a separate local government that delivers public services to a particular area.

Special districts can be distinguished by their four common characteristics:

- A form of government.
- Governed by a board.
- Provides services and facilities.
- Has defined boundaries.

Inadequate tax bases and competing demands for existing taxes make it hard for cities and counties to provide all the services their citizens desire. When residents or landowners want new services or higher levels of existing services, they can form a district to pay for them. Fire districts, irrigation districts, and pest abatement districts exist today because taxpayers were willing to pay for public services they wanted. Special districts localize the costs and benefits of public services. Special districts allow local citizens to obtain the services they want at a price they are willing to pay.

So, what’s so special about special districts? Focused services. Special districts are a type of local government that delivers specific public services within defined boundaries.

Special districts deliver highly diverse services including water, closed captioned television, mosquito abatement, and fire protection. Most special districts serve just a single purpose, such as sewage treatment. Others address a multiplicity of needs, as in the case of community service districts, which can offer up to 16 different services. Districts' service areas can range from a single city block to vast areas which cross city and county lines. For example, the Metropolitan Water District of Southern California serves nearly 17 million people in over 5,200 square miles of six counties, while County Service Area #2 in Los Angeles County serves only 25 acres.

Special districts enjoy many of the same governing powers as other cities and counties. They can enter into contracts, employ workers, and acquire real property through purchase or eminent domain. They can also issue debt, impose taxes, levy assessments, and many charge fees for their services. Special districts, like other governments, can sue and be sued. They can also adopt a seal and alter it at will!

Special districts have the corporate power and tax power but rarely the police power. The corporate power is the ability to "do things," like constructing public works projects such as dams and sewers. It's the power to deliver recreation programs and collect garbage. The tax power is the authority to raise money to pay for these projects and services. The police power is different; it's the authority to regulate private behavior to accomplish a public goal. Governments that make rules and enforce them use the police powers: zoning property, requiring business licenses, or setting speed limits. Special districts rarely have police powers. Instead, they usually build public facilities and provide services. When special districts do have police powers, they are usually related to some corporate power. Banning alcohol from a park district's picnic area is one example.
WHAT A SPECIAL DISTRICT IS NOT

Now that we understand what special districts are, let's examine what special districts are not.

- **Special districts are not state government.**

Special districts are local agencies which provide public services to specific communities. Special districts are autonomous government entities, accountable only to the voters or landowners they serve. State government, however, oversees special districts in several ways. For example, special districts must submit annual financial reports to the State Controller. Districts must also follow the state laws pertaining to public meetings, bonded debt, record keeping, and elections.

- **Special districts are not city or county government.**

Cities and counties are *general purpose* governments. Cities and counties perform a broad array of services to protect the health, safety, and welfare of all their citizens. Special districts are *limited purpose* local governments. Special districts provide only the services their residents desire. Certain types of special districts require that the city council or county supervisors serve as their governing boards. Nevertheless, special districts remain legally separate local entities.

- **Special districts are not school districts.**

School districts exist to provide one service --- public education. Special districts provide a variety of public services, excluding education. In addition, school districts get most of their money from the state, whereas special districts rely primarily on local revenues.

- **Special districts are not "Mello-Roos" districts or benefit assessment districts.**

California law allows cities, counties, school districts, and many special districts to establish Mello-Roos districts and benefit assessment districts to finance public works and public services. Mello-Roos districts and benefit assessment districts are solely financing mechanisms and do not deliver services. Special districts use these financing mechanisms to provide public services.

- **Special districts are not redevelopment agencies.**

Cities and counties set up redevelopment agencies to eliminate blight by paying for public and private improvements and economic development. Special districts do not exist to eliminate blight. Special districts provide public services and infrastructure that help communities, but they are not in the business of direct economic development.

- **Who’s in, who’s out?**

Most of the data on special districts in this report comes from the annual Special Districts Annual Reports produced by the State Controller’s Office. The total number of special districts included in this citizens guide (3,361) varies from the State Controller’s report (4,792) because they define special districts differently. The State Controller’s report has a very broad reach, including many organizations that aren’t really special districts. This guide omits districts that don’t share all four of the key characteristics: provides services, has boundaries, is a form of government, has a board. This citizens guide omits the 31 Air Pollution Control Districts because they are regulatory agencies not service districts. Similarly, nonprofit corporations don’t appear in our count because they are corporations not governments.
**HISTORY OF SPECIAL DISTRICTS IN CALIFORNIA**

Like hula hoops, martinis, and freeways, special districts became an art form in California. Special districts first arose in California to meet the water needs of farmers in the San Joaquin Valley. Frustrated by an inconsistent water supply and widely varying prices, farmers in Stanislaus County organized the Turlock Irrigation District under the Wright Act of 1887. The Wright Act allowed a majority of residents in an area to form a public entity for water delivery, and to finance its operation through bond sales. The Turlock Irrigation District made it possible for San Joaquin Valley farmers to intensify and diversify their agricultural activities.

Following the development of districts such as the Turlock Irrigation District, new water district formation shifted away from rural, agricultural lands, towards water-deficient communities in urban areas. In the early 1900s, water districts were primarily located in northern and central California. After 1950, they spread to Southern California to satisfy the suburbs' growing demand for water.

In the 20th Century, special districts increased dramatically in both number and scope. The prosperity that followed World War II increased the demand for public services of all kinds and, consequently, special districts. Special districts became a popular way to meet these incremental needs because, unlike complex municipal bureaucracies, special districts were flexible and provided desired services quickly and efficiently.

The decade after World War II saw an expansion in district activities for fire protection, sanitation, and water supply. Mosquito abatement districts, though first formed in 1915, multiplied to combat diseases inadvertently imported by returning soldiers. Hospital districts arose in 1945 because of a statewide shortage of hospital beds. Population growth in unincorporated areas spurred the development of recreation and park districts. Created to address individual service needs, special districts grew to encompass multiple needs as well. The Municipal Utility District Act of 1921 allowed special districts to diversify and address multiple needs ranging from water, power, transportation, and telephone service, as well as "all things necessary and convenient."

**STATUTORY AUTHORITY FOR SPECIAL DISTRICTS**

Special districts operate either under a principal act or a special act. A principal act is a generic statute which applies to all special districts of that type. For example, the Fire Protection District Law of 1987 in the state Health and Safety Code governs all 386 fire districts. There are about 60 principal law statutes which can be used anywhere in the state to create a special district.

Occasionally, local circumstances fail to fit the general conditions anticipated by a principal act. In those cases, the Legislature may create a special act district tailored to the unique needs of a specific area. Districts which are regional in nature, have specific governing board requirements, provide unique services, or need special financing, necessitate special laws for formation. Districts formed under a special act include: the Humboldt Bay Harbor Recreation and Conservation District, the Fairfield-Suisun Sewer District, and the Alameda County Flood Control and Water District. There are about 120 special act districts.
All principal acts appear as laws in the California State codes, whereas most special acts are not codified. However, for convenience, many of the special acts for water districts appear in the Appendix to the California Water Code. For a complete listing of these acts, see Appendix A in the State Controller’s Special Districts Annual Report.

**TYPES OF SPECIAL DISTRICTS**

Special districts’ activities are as diverse as the communities they serve. The most common type of special district in California is the County Service Area (897), while districts with unique functions include the bridge and highway authority (1).

With about 3,400 special districts, it may seem overwhelming to try to understand the purpose and function of the districts. So, to simplify, let’s break down the districts into pairs of categories. One way of understanding districts is to look at their various contrasting features:

- Single function versus multi-function.
- Enterprise versus non-enterprise.
- Independent versus dependent.

**Single Function versus Multi-Function Districts**

Nearly 85% of California’s special districts perform a single function. Single function districts provide only one service such as water, sewage, or fire protection. The Happy Camp Cemetery District in Siskiyou County is an example of a single function special district. The only service that the 253 public cemetery districts can provide is cemeteries.

Multi-function districts provide two or more services. County Service Areas (CSAs) may provide any service which a county can provide. For example, CSAs provide extended police protection, enhanced library facilities, parks, and television translator services.

![Single function v. Multi function Special Districts](image)

Source: 1996-97 State Controller’s Special Districts Annual Report
Some multi-function districts only offer a few of the services they are authorized to provide. For example, the Buzztail Community Service District in Butte County is authorized under the Community Service District Law to provide up to 16 services and yet it offers only water service. The powers which a district is authorized to use but does not currently employ are called **latent powers**. Special districts can usually enact latent powers by vote of the district board. In some cases, however, district voters must approve new powers.

**Enterprise versus Non-enterprise Districts**

Just over a quarter of the special districts are enterprise districts. Enterprise districts deliver services that are run like a business enterprise; they charge for their customers’ services. For example, a hospital district charges room fees paid by patients, not the district’s other residents. Water districts charge water rates to their customers. Virtually all water, waste, and hospital districts are enterprise districts.

![Enterprise vs. Non-enterprise Districts](source: 1998-99 State Controller’s Special Districts Annual Report)

Non-enterprise districts provide services which don't lend themselves to fees. Fire protection services and mosquito abatement programs benefit the entire community, not just individual residents. No direct cost/benefit relationship exists in the services provided by non-enterprise districts. Consequently, non-enterprise districts generally don’t charge user fees for their services. No one wants to put a meter on a park district’s swings or charge residents to put out a house fire. Non-enterprise districts rely overwhelmingly on property taxes for their operational expenses. Services commonly provided by non-enterprise districts include fire protection, cemeteries, libraries, and police protection. Though non-enterprise districts rely primarily on non-fee revenue, certain services, such as a park district's pool, can generate a small amount of fee revenue.

**Independent versus Dependent Districts**

About two-thirds of the state’s special districts are independent districts. Independent districts have their own separate boards of directors elected by the districts’ own voters. Independent districts also include districts where the appointed boards of directors serve for fixed terms. The cemetery districts are independent districts with this governance structure. Special districts’ governing boards can vary with the size and nature of the district. Most districts have five-
member governing boards. Other governing boards vary from three to 11 members. The Metropolitan Water District of Southern California, which has 37 board members, is unique.

Dependent districts are governed by other, existing legislative bodies (either a city council or a county board of supervisors). All County Service Areas, for example, are dependent districts because their county boards of supervisors govern them. The Yucca Valley Recreation and Park District is governed by the San Bernardino County Board of Supervisors, making it a dependent district. The Oceanside Small Craft Harbor District is another dependent district that is run by the Oceanside City Council. A community's registered voters usually choose an independent district’s board of directors. But in some water districts, political power rests with the local landowners. Where the districts' services primarily benefit landowners' land and not people, the courts have upheld the use of these landowner-voter districts. Larger independent districts often have a professional manager, similar to a city manager or a county administrator, to assist the board members. The governing boards adopt broad policies that the general managers carry out. Different types of independent special districts include library districts, resource conservation districts, and memorial districts.

Who has the right to vote?

The issue of landowner-voter districts was called into question in the US Supreme Court case, Salyer Land Company v. Tulare Lake Basin Water Storage District (1972).

The plaintiffs were landowners and resident registered voters within the District who claimed that it was unconstitutional for the District to restrict voting rights to landowners only. Further, they argued that it was inequitable that smaller landowners received fewer votes than larger landowners. The plaintiffs urged the creation of a new policy so that all residents in the District would be permitted only one vote regardless of land ownership.

The defendant District argued that its services benefited the land only. Thus, any effects on non-landowner residents were indirect and did not entitle them to vote. Also, the number of votes allotted to landowners was proportional to the assessed value of the land, and therefore relative to the benefits and burdens to each landowner.

The US Supreme Court agreed with the defendant and upheld landowner-voting because the District "provides no service to the general public."

These three distinctions about special districts are certainly not mutually exclusive. It is possible to have an independent, multifunction, enterprise special district, such as the Whispering Palms Community Service District in San Diego County. The District is independent because it the
local voters elect their own board of directors; it’s *multifunction* because the District provides sewers, street lighting, and road maintenance; and it’s *enterprise* because local officials charge their customers for the sewer services. Conversely, County Service Area # 19 in Marin County is a dependent, single function, non-enterprise district. The CSA is *dependent* because the Marin County Board of Supervisors governs it; it’s *single function* because it delivers only one service; and it’s *nonenterprise* because that sole service is fire protection.

**FUNDING SPECIAL DISTRICTS**

Special districts generate revenue from several sources. Some collect fees to fund their activities, while others rely more heavily on property tax revenues.

Both enterprise and non-enterprise districts can issue bonds to pay for capital improvements. These bonds can pay for a new dam or purchase a new library building. Special districts’ total long-term bonded debt is approximately $13 billion. Special districts’ *general obligation bonds* are backed by property taxes and require 2/3-voter approval. Special districts’ *revenue bonds* are paid from user fees and don’t necessarily need voter approval.

Enterprise districts rely primarily on non-tax revenues, such as user charges. Because enterprise districts’ costs are directly related to the services provided, it is easy for enterprise districts to recoup their costs by collecting fees. For example, the Sacramento Municipal Utility District sells the electricity it produces to the District’s customers. Enterprise revenues generated by enterprise districts in 1997-98 were nearly $14 billion.

**Enterprise Districts’ Enterprise Revenues (1997-98)**

<table>
<thead>
<tr>
<th>Service</th>
<th>Dollars in millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>$4,802</td>
</tr>
<tr>
<td>Transit</td>
<td>$2,436</td>
</tr>
<tr>
<td>Waste disposal</td>
<td>$2,278</td>
</tr>
<tr>
<td>Electric utility</td>
<td>$2,257</td>
</tr>
<tr>
<td>Hospital</td>
<td>$1,739</td>
</tr>
<tr>
<td>Airport</td>
<td>$169</td>
</tr>
<tr>
<td>Harbor and port</td>
<td>$139</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$13,820</strong></td>
</tr>
</tbody>
</table>

*Source: 1997-98 State Controller’s Special Districts Annual Report*

Non-enterprise districts rarely bill the beneficiaries of their services. Non-enterprise districts rely primarily on property taxes to pay for their operation and maintenance costs. Tax revenues used by non-enterprise districts come through regular property tax allocations.

**Loss of Funding for Special Districts**

Many special districts have faced tough financial times over the last quarter century. Before Proposition 13, special districts received $945 million from property taxes (1977-78). In 1978-79, their property tax revenues dropped to $532 million, a loss of almost 50%.

Responding to this financial hardship, the Legislature created the Special District Augmentation Fund (SDAF) to provide a supplemental income for special districts. The state government sent
One special district that has been particularly devastated by the ERAF shift is the Fulton-El Camino Recreation and Park District in Sacramento County.

This District lost more than $2.9 million in property tax revenue to ERAF between 1992-93 and 2001-02. As a non-enterprise district, it cannot recover these losses with service charges.

This revenue loss has caused the District to demolish the Howe Pool, and it may have to fill another swimming pool. The District lacks money to repair aging facilities and attract quality employees. The lack of funds threatens the public safety at its recreation facilities.

Reserves: How much is too much?

Special districts’ financial reserves have become controversial. In 2000, a report by the Little Hoover Commission revealed that special districts reported more than $19.4 billion in reserves to the State Controller in 1996-97. Enterprise special districts, which charge fees, hold most of the reserves.

This large dollar figure raised a red flag for policymakers and the public. Why were the districts setting aside so much money? And how were they planning to spend it?

In response, special district leaders argued that there are legitimate reasons for these reserves. Nearly all of the state money to the SDAF in each county based on a formula in state law. The county supervisors, in turn, allocated the SDAF money to the special districts within their counties. The State took over a greater percentage of funding for schools from local governments to help local governments get through the Proposition 13 transition. This practice lasted from 1978 to 1992.

Faced with huge state budget deficits in 1992-93 and 1993-94, state officials shifted almost $4 billion annually in property taxes from local governments (cities, counties, special districts, and redevelopment agencies) to an Educational Revenue Augmentation Fund (ERAF) in each county. The property tax revenue in the ERAF supports schools. ERAF helps the state government fulfill its constitutional duty to fund schools. When the Legislature abolished SDAF in 1993-94, the state transferred $244 million in special district property tax revenues to schools. Because non-enterprise special districts rely almost entirely on property tax revenues, many were fiscally devastated as a result of the ERAF funding shifts. (See the box above.) Enterprise special districts were better able to make up for the lost revenue because they have fees that generate revenue and they rely less on property taxes.

Although state legislators have granted some partial relief to special districts, ERAF’s fiscal consequences remain especially harsh for non-enterprise districts. In 2000, Governor Gray Davis vetoed a bill that would have capped ERAF shifts. In 2001, bills that would have helped fire districts, library districts, and recreation and park districts failed to pass. The ERAF issue remains unsolved.

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Much Ado About Nothing?

The Metropolitan Water District of Southern California (Met) entered the public spotlight when the Little Hoover Commission report revealed that it held $4 billion in reserves.

But, according to Met, that figure actually reflected all of Met’s earnings (not just cash reserves). This figure included the district’s capital assets like the Colorado River Aqueduct and expensive water filtration plants. The cash reserves were actually just under $1 billion.

As a large special district that serves the highly populated Southern California region, Met claims its reserves are a hedge against volatile water markets. Fluctuating weather patterns cause shortfalls that would create price spikes for customers in the absence of a Water Rate Stabilization fund, which uses reserve money.
money in reserves was allocated into specific funds for given purposes. Large reserves are needed to accumulate the capital to pay for large public works projects. Reserves also provide a safety cushion in lean years, stabilizing consumers’ rates.

It became clear to taxpayers and legislators that special districts should improve the way they report their fiscal activities. Specifically, they need to explain the purpose of the reserves. Out of this controversy came a new law that now requires the largest special districts to report their reserves and fiscal information more descriptively to the State Controller’s Office, which will post the information on its web site.

**LAFCO Cost-Sharing**

Starting in January 2001, cities, counties, and special districts each pay one-third of the costs of the Local Agency Formation Commission (LAFCO), where they have representation on the Commission. For decades, the county governments had always paid 100% of LAFCOs’ costs. Many consider this new formula to be a more equitable way of paying for LAFCOs.

Special districts’ one-third share of the LAFCO costs is divided among the districts in that county. A given district’s contribution is proportionate to the district’s revenue. For this reason, some special districts must pay what they say are disproportionate amounts. For example, the Sacramento Municipal Utility District, an enterprise district that serves a large number of customers, pays for nearly 85% of the special districts’ share of the Sacramento LAFCO budget. Similarly, hospital districts in Sonoma County pay more than other special districts.

**ADVANTAGES AND DISADVANTAGES OF SPECIAL DISTRICTS**

Many people disagree over the usefulness and desirability of special districts. Before you make up your own mind, consider these arguments.

**ADVANTAGES:**

- **Special districts can tailor services to citizen demand.**

Cities and counties must protect their residents’ health, safety, and welfare and, thus, must provide many services, regardless of citizen demand. Special districts, however, only provide the services that the community desires.

- **Special districts can link costs to benefits.**

General purpose local governments --- cities and counties --- levy general taxes to pay for public services. The services that taxpayers receive are not directly related to the amount of taxes they pay. In a special district, only those who benefit from district services pay for them. Those who do not benefit do not pay.

- **Special districts are responsive to their constituents.**

Because most special districts are geographically smaller and have fewer residents than counties and cities, they can be more responsive to their constituents. Small groups of citizens can be quite effective in influencing special districts' decisions.
DISADVANTAGES:

- Special districts can lead to inefficiency.

Many special districts provide the same services that cities and counties provide. Overlapping jurisdictions can create competition and conflict between special districts, and also between districts and general purpose governments. In addition, when communities incorporate, some Local Agency Formation Commissions (LAFCOs) fail to dissolve the special districts that exist within the new city boundaries, resulting in duplicated services.

- Special districts can hinder regional planning.

Having numerous special districts can hamper planning efforts. For example, it can be difficult to organize the various water, sewer, and fire services in one region to provide equitable services for all residents. Because about 2/3 of the districts have independent governing boards, there is no single agency which can guarantee a coordination of efforts.

- Special districts can decrease accountability.

The multiplicity of limited purpose special districts can make it harder for citizens to gather information. Separate special districts may provide water, sewer, parks, library, and fire protection services to the same unincorporated community. Residents have a hard time finding out who’s in charge. Furthermore, the narrow and technical nature of a district’s activities often results in special districts with low visibility until a crisis arises. Special district elections typically have very low voter turnout. Although some view low voter turnout as a sign of voter satisfaction, representative democracy requires broad participation.

FREQUENTLY ASKED QUESTIONS

Now that you have a basic understanding of special districts, you may have some specific questions you’d like answered. Here are nine of the most frequently asked questions.

1. How do I find out if I live in a special district?

The easiest way to find out if you live in a special district is to call your Local Agency Formation Commission (LAFCO). This office exists in every county and is responsible for forming and dissolving special districts within that county. You can find a directory of LAFCOs at: www.calafco.org.

2. How can I form a special district?

District formation follows five steps:

1. Application: Registered voters in the proposed district apply to the Local Agency Formation Commission (LAFCO). The application must detail the proposed district's boundaries and services, any environmental effects, and financing options.

2. Review and approval: The LAFCO’s staff studies the application, and schedules a public hearing. The LAFCO can approve or deny the proposal. If the LAFCO approves, it’s time to measure protests.

3. Protest hearing: The LAFCO holds a second public hearing, this time to measure formal protests from voters and property owners. A majority protest stops the proposal, otherwise there’s an election.

4. Election: Only the voters inside the proposed district’s boundaries vote at this election, which usually requires majority-voter approval. If the proposal involves new special taxes, the measure needs 2/3-voter approval.
5. **Formal filing:** If the voters approve the proposed district, the LAFCO and other officials file the formal documents to start the new district.

3. **Who picks my district's governing board?**

About 2/3 of our special districts are **independent**, that is, they have independently elected or appointed boards of directors. The other districts are **dependent** districts because they depend on another local government to govern them; usually a city council or a county board of supervisors. In most independent districts, registered voters elect the governing boards. In a few types of special districts, the landowners vote. Most governing boards have five members who serve staggered, four-year terms.

4. **How can I find out who runs a special district?**

The easiest way is to call the district directly and ask who serves on the district's governing board. You can find the telephone number in the white pages of your telephone book. Also, your county clerk keeps a formal Roster of Public Agencies which lists all special districts and the names and addresses of the members of the districts’ governing boards. Ask your county clerk for a copy of your county's Roster. This information may also be available on your county’s web site.

5. **Can special districts tax me without my consent?**

No. Proposition 13 (1978) limited property taxes to 1% of property value. Many special districts get a share of these revenues. If a special district wants additional taxes, Proposition 13 and state law require 2/3-voter approval for "special taxes." A general obligation bond that raises property taxes also requires 2/3-voter approval.

6. **But what about special assessments? Aren't they like special taxes?**

Not really. Special districts can charge benefit assessments to pay for public works like sewers, parks, and water systems. Property owners pay benefit assessments only for the projects or services that **directly** benefit their property. The amount of the assessment must be directly related to the benefit received. Proposition 218 (1996) required local governments, including special districts, to get weighted ballot approval from property owners before they can levy benefit assessments.

7. **Suppose I don't like what a special district is doing. What can I do?**

Talk to your district representative, the district's general manager, or the district board at its next meeting. If you still aren't pleased with your district's activities, the remedy is direct democracy in the form of **initiative, referendum, and recall.**

- The **initiative** power lets citizens propose ordinances directly instead of waiting for the district board to act. Initiative drives follow this pattern: notice, petition, and election.

- **Referenda** also give citizens a direct vote in district matters. The referendum power lets citizens put recent board actions on the ballot and reject them **before** they go into effect. Referendum procedures are similar to the initiative process.

- The **recall** power allows voters to remove board members from office before the next election. Elected board members may be relieved of their duties by a process similar to those for initiatives and referendums.
8. Why are special districts so invisible to the public?

Special districts often escape wide public attention because their functions are narrow and technical. Special districts, however, must conform to democratic safeguards such as the Brown Act, the Public Records Act, and the Political Reform Act. For more information on access to government meetings and documents, the Senate Local Government Committee has produced citizen guides to the Brown Act, the Public Records Act, and conflict-of-interest laws. These reference books can be obtained from the Senate Publications Office at (916) 327-2155.

9. Where can I get more information about special districts in my area?

The following organizations can give you more information on special districts:

Resources in your city or county:
- Local Agency Formation Commission (LAFCO).
- County Board of Supervisors.
- City Council.

Resources in Sacramento:
- California Special Districts Association.
- Association of California Water Agencies.
- California Association of Sanitation Agencies.
- Mosquito and Vector Control Association of California.

Web sites for several of these above organizations appear in Appendix B.

For more detailed information about the number and types of special districts around the state, you may contact the Office of the State Controller at (916) 445-3028. Every year the Controller's Office publishes a Special Districts Annual Report. You can find copies of these reports in many major public libraries.

CURRENT ISSUES AND EMERGING TRENDS

As you are now aware, special districts are a highly diverse form of local government. Although it is difficult to generalize about trends affecting special districts, here are some general themes and issues:

• Formation. There is a lingering public perception that the number of special districts is growing, particularly independent special districts, contributing to increased bureaucracy and inefficiency. The truth is that the overall number of special districts has edged down from 3,454 districts in 1977-78, to 3,359 in 1997-98. And the number of independent districts has dropped by more than 150 in the past twenty years, going from 2,340 districts to 2,176 in 1997-98.

Since the 1980s, newly formed special districts have been primarily revenue-generating districts. Proposition 13's limits on property taxes forced special districts to find other ways to raise money to pay for services. Enterprise districts, as well as community service districts and county service areas, have become increasingly popular due to their flexibility, broad range of service, and ability to generate user fees.
• **Cooperation.** Special districts are overcoming their sense of isolation and are forming associations to discuss common problems and ways to improve service. Some groups represent special districts in a single county. Districts in Butte, San Diego, and Ventura County all have active groups. Statewide organizations such as the California Special District Association, the Association of California Water Agencies, and the Mosquito and Vector Control Association of California serve special districts across the state. Special district associations also exist on the national level.

• **Land use planning.** Some experts feel that public works, not public policy, determine the location, timing, and intensity of development. Because special districts are a major provider of public works such as water and sewers, they can have a significant effect on local development. Cities and counties control land use within their borders by adopting general plans. Special districts, however, can ignore or override local land use controls. Though some districts are governed by the same board or council that adopts the general plan, the majority have independent governing bodies which may have different development ideas. Though most independent districts work well with their city and county governments, the potential for inconsistency exists.
## APPENDIX A: SPECIAL DISTRICTS BY TYPE, 1998-99

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Count</th>
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<tr>
<td>County Service Area</td>
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</tr>
<tr>
<td>Fire Protection</td>
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<td>Community Services</td>
<td>313</td>
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<tr>
<td>Cemetery</td>
<td>253</td>
</tr>
<tr>
<td>County Water</td>
<td>174</td>
</tr>
<tr>
<td>California Water</td>
<td>141</td>
</tr>
<tr>
<td>Reclamation</td>
<td>152</td>
</tr>
<tr>
<td>Recreation and Park</td>
<td>110</td>
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<tr>
<td>Resource Conservation</td>
<td>99</td>
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<tr>
<td>County Sanitation</td>
<td>91</td>
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<tr>
<td>Irrigation</td>
<td>97</td>
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<tr>
<td>Sanitary</td>
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<tr>
<td>Hospital</td>
<td>77</td>
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<tr>
<td>Public Utility</td>
<td>54</td>
</tr>
<tr>
<td>Mosquito Abatement</td>
<td>47</td>
</tr>
<tr>
<td>Storm Water Drainage and Conservation</td>
<td>49</td>
</tr>
<tr>
<td>County Waterworks</td>
<td>34</td>
</tr>
<tr>
<td>Municipal Water</td>
<td>40</td>
</tr>
<tr>
<td>Flood Control and Water Conservation</td>
<td>39</td>
</tr>
<tr>
<td>Water Agency or Authority</td>
<td>30</td>
</tr>
<tr>
<td>Memorial</td>
<td>27</td>
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<tr>
<td>Drainage</td>
<td>23</td>
</tr>
<tr>
<td>Levee</td>
<td>15</td>
</tr>
<tr>
<td>Harbor and Port</td>
<td>13</td>
</tr>
<tr>
<td>Library</td>
<td>13</td>
</tr>
<tr>
<td>Transit</td>
<td>13</td>
</tr>
<tr>
<td>Water Conservation</td>
<td>13</td>
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<tr>
<td>Airport</td>
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<td>Water Storage</td>
<td>8</td>
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<td>Citrus Pest Control</td>
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<tr>
<td>Waste Disposal</td>
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<tr>
<td>Pest Control</td>
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<td>Municipal Improvement</td>
<td>5</td>
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<tr>
<td>Municipal Utility</td>
<td>5</td>
</tr>
<tr>
<td>Police Protection</td>
<td>3</td>
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<tr>
<td>Sanitation and Flood Control</td>
<td>2</td>
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<tr>
<td>Sewer</td>
<td>2</td>
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<tr>
<td>Water Replenishment</td>
<td>2</td>
</tr>
<tr>
<td>Bridge and Highway</td>
<td>1</td>
</tr>
<tr>
<td>Joint Highway</td>
<td>1</td>
</tr>
<tr>
<td>Metropolitan Water</td>
<td>1</td>
</tr>
<tr>
<td>Separation of Grade</td>
<td>1</td>
</tr>
<tr>
<td>Toll Tunnel Authority</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3,361</strong></td>
</tr>
</tbody>
</table>
APPENDIX B: WEB SITES AND RESOURCES RELATED TO SPECIAL DISTRICTS

- University of California, Institute of Governmental Studies, California Local Government Information Web site:
  http://www.igs.berkeley.edu:8880/library/localweb.html

  109 Moses Hall #2370
  Berkeley, CA 94720-2370
  (510) 642-1472
  (510) 643-0866

- Association of California Water Agencies (ACWA):

  910 K Street, Suite 100
  Sacramento, CA 95814-3512
  (916) 441-4545

- California Special Districts Association (CSDA):
  http://www.csda.net/links.htm

  1215 K Street, Suite 930
  Sacramento, CA 95814
  (916) 442-7887

- California Governor’s Office of Planning and Research—Local Agency Formation Commissions (LAFCO) Directory:
  http://ceres.ca.gov/planning/bol/1999/lafco.html

  P.O. Box 3044
  Sacramento, CA 95812-3044
  Ph: (916) 445-0613

- California Association of LAFCOs:
  http://www.calafco.org

  c/o San Joaquin LAFCO
  1860 East Hazelton Avenue
  Stockton, CA 95205
  Ph: (209) 468-3198
  Fax: (209) 468-3199

- Text Resources:

  The San Diego LAFCO publishes a LAFCO Procedures Guide which provides a general introduction to special districts and local government. Contact the San Diego LAFCO directly: County Administration Center, 1600 Pacific Highway, Room 452, San Diego, CA 92101. Ph: (619) 531-5400, Fax: (619) 557-4190.
APPENDIX C: REFERENCES FOR QUESTIONS

The section entitled, "Frequently Asked Questions" on pages 11-13 tried to anticipate many of your questions about special districts. Here is a list of references we used to answer the questions.

Statutes are listed by code followed by section. For example, "Government Code §34601" means that you can find the statute under Section 34601 of the Government Code. When reading the code, start by looking at the back of the book in the "pocket part." The pocket section has the latest versions of the statutes, including recent amendments and deletions.

Question #2
References:
Cortese-Knox-Hertzberg Local Government Reorganization Act
Government Code §56000

Question #3
References:
Uniform District Election Law
Elections Code §10500

Question #5
References:
California Constitution Article XIII A (Proposition 13)
Revenue and Taxation Code §95 (property tax allocation)
Government Code §50075 (special taxes)
Revenue and Taxation Code §96.3 and §96.31 (bonded debt)

Questions #6
References:
California Constitution Article XIII D (Proposition 218)
Government Code §53753 (weighted ballots)

Question #7
References:
Elections Code §9300 and §9340 (initiative and referendum procedures)
Elections Code §11000 (recall procedures)
ACKNOWLEDGMENTS

Kimia Mizany prepared the Third Edition of this citizens guide. She worked from the First and Second Editions, prepared by April Manatt, formerly a consultant to the Senate Local Government Committee. The Third Edition benefited from the generous contributions from the following individuals:

- Peter Banning, Marin County LAFCO
- Wayne Beck, State Controller's Office
- Candace Carpenter, Senate Local Government Committee
- Cathy Cole, Metropolitan Water District of Southern California
- Peter Detwiler, Senate Local Government Committee
- Elvia Diaz, Senate Local Government Committee
- Jeff Dubchansky, Fulton-El Camino Recreation and Park District
- Greg Foell, Fulton-El Camino Recreation and Park District
- Ralph Heim, Heim, Noack, Kelley & Spahn
- Nancy Lyons, Little Hoover Commission
- April Manatt, Grenada Hills
- Ralph Miller, California Association of Recreation and Park Districts
- Marianne O’Malley, Legislative Analyst’s Office
- Bob Reeb, Association of California Water Agencies
- Catherine Smith, California Special Districts Association

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Model for Estimating Evaporation and
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The Promise of Regulated Deficit Irrigation in
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By David Goldhamer and Elias Fereres, UC Davis, IAS-CSIC and University of Cordoba, Spain ............................................................ 207

SIMETAW (Simulation of Evapotranspiration of Applied Water)
By Richard Snyder, Morteza Orang, Shu Geng, Scott Matyac and Sara Sarreshteh, UC Davis and DWR ............................................................ 211
Introduction by Scott Matyac, DWR
Introduction

by Scott Matyac, Department of Water Resources

California farmers must find ways to continue profitable production in the face of a less abundant and increasingly costly water supply. At the same time, they are obliged to help maintain water quality by minimizing the leaching of salts and chemicals from the soil surface and root zone into the water supply. A key to better agricultural water management lies in improving our understanding of evapotranspiration, the process that drives crop water use. The articles in this section of the Reference Guide help to answer some questions on this important topic.

What is evapotranspiration?

Crop water use is directly related to the water lost though the process of evapotranspiration (ET), a combination of evaporation from the soil surface and transpiration from plant leaves. The amount of water consumed through ET depends in the short term on local weather and in the long term on climatic conditions. Energy from solar radiation is the primary factor that determines the rate of crop ET. Also important are humidity, temperature, wind, stage of crop growth, and the size and aerodynamic roughness of the crop canopy. Irrigation frequency affects ET after planting and during early growth because evaporation increases when the soil surface is wet and exposed to sunlight. Growing season ET varies significantly among crop types, depending primarily on how long the crop actively grows.

How is ET quantified?

Direct measurement of crop ET requires costly investments in time and sophisticated equipment. However, several new methods are available for estimating ET using local weather information and radiation data gathered by Earth orbiting satellites. In “Consumptive Use Program Model”, Orang and others describe a computer application for estimating crop ET in California. The model is in the form of a user-friendly MS-Excel spreadsheet that incorporates the latest crop coefficients and better accounts for evaporation from bare soil during the early growing season. “Simulation of Evapotranspiration of Applied Water” documents the work of Snyder and others to develop a weather generator model that simulates daily weather data from monthly climate data. The model, known by the acronym SIMETAW, shows promise for evaluating how climate change might affect crop ET and irrigation water needs in California. Other avenues of research include the use of satellite data to identify crop types and estimate crop ET. “Central Valley Crop Classification Processing Using Remote Sensing and GIS Technologies” details a cooperative effort by the U.S. Bureau of Reclamation and the California Department of Water Resources to remotely identify crop types with better than 90 percent accuracy. This method may prove to be a cost effective alternative to the current practice of “on-the-ground” surveys of cropping patterns. “Evapotranspiration from a satellite-based surface energy balance for the Snake River Plain Aquifer in Idaho” describes the development and application of METRIC™, an image processing tool that combines data from Earth orbiting satellites and ground-based weather stations to estimate ET from crops, landscape, and native vegetation. METRIC™ has been applied on a limited basis in the Imperial Valley of California, and may be applicable to other important agricultural regions such as the Central Valley.
Should (and can) E and T be analyzed separately?

Rainfall and irrigation water received by farmland is consumed by evaporation from the soil and transpiration from plant leaves. Though distinct, the two processes are usually analyzed collectively due to the difficulty in accounting for each process separately. Crop production is closely associated with transpiration because plants grow by assimilating carbon dioxide from the air via photosynthesis.

However, the water lost by evaporation does not directly benefit crop growth, raising the question of whether reducing evaporation might help to stretch California’s agricultural water supply. In “Evaporation Research – a Review and Interpretation”, Burt and others observe that the majority of annual evaporation is from rainfall and suggest that only a portion of evaporation may be conservable. They point out that transpiration decreases with increasing evaporation, but the tradeoff is not equal – the increase in E is typically greater than decrease in T. In a study supported by DWR, Hsiao and Xu studied the extent to which ET is suppressed while water is applied by sprinklers. Their article, “Evapotranspiration and Relative Contribution by the Soil and the Plant”, discusses a method to estimate the extent to which crop T is likely to be increased by minimizing soil E. Ventura and others note that estimating vegetable crop ET is difficult because soil evaporation is high due to frequent irrigations. They also indicate that previous models for separately estimating E and T tend to require many crop and soil parameters that are not commonly available. Their article, “Model for Estimating Evaporation and Transpiration from Row Crops”, describes the development of a model that better accounts for soil evaporation and requires only daily reference evapotranspiration as input.

In “Limits to the Productivity of Water in Crop Production”, Keller and Seckler tackle the question "Will increased crop yields simultaneously create increased water scarcity because of increased transpiration?" They note that historical increases in crop yields have been accompanied by increased water productivity. However, they conclude that in highly developed agricultural areas the potential for substantial water savings is small and that yield increases will simultaneously increase transpiration and therefore contribute to water scarcity.

Can transpiration be reduced without harming agriculture?

The close relationship between crop transpiration and photosynthesis is reflected in the near linear relationship between crop yield and crop ET. In most field and row crops, reducing transpiration through water stress is associated with reduced production in terms of crop quality or yield. In “The Promise of Regulated Deficit Irrigation in California’s Orchards and Vineyards”, Goldhamer and Fereres note that it is possible to reduce transpiration of trees and vines without reducing yield. They conducted Regulated Deficit Irrigation (RDI) research on the major tree crops in California – pistachio, olive, prune, and citrus – and identified numerous species where water can be saved without a negative impact on production or grower profit. RDI is already used by many California growers to stress trees or vines at specific developmental stages in order to improve crop quality, decrease disease or pest infestation, or reduce production costs. For example, mild stress is imposed on wine grapes through the growing season which decreases canopy growth and produces smaller berries with higher sugar content, better color, and higher skin to fruit-volume ratio. Further research may reveal the potential for orchard and vineyard RDI in managing California’s agricultural water supply.
Evapotranspiration is the primary consumptive use of irrigation water and rainfall on agricultural land. The articles in this section document recent research that sheds new light on the interrelationships between evaporation, transpiration, and crop production. A common thread is that there remains considerable potential for translating increased understanding of crop water use into a more reliable and productive agricultural water supply.
The Amount of Water We Eat
By John Letey and David Birkle. Originally published in Currents, A Newsletter of the University of California Water Resources Center (Winter 2003, Volume 4, Issue 1)
The Amount of Water We Eat
By John Letey and David Birkle

The fact that the amount of water used in growing agricultural crops in California is much greater than the amount of water used in cities is well publicized. Values of 80-85 percent of developed water going to agriculture are commonly reported. Less understood is the fact that large quantities of water are indirectly delivered to the city via food. The late professor Robert Hagan recognized this and was instrumental in initiating a study to quantify the water used to produce various foods in California.

Marcia Kreith, with guidance from an advisory committee, which Professors Robert Hagan and Henry Vaux Jr. co-chaired, prepared a report for the Water Education Foundation dated September 27, 1991, entitled “Water Inputs in California Food Production.” The assumptions made for the analyses are reported in detail. The basic approach was to divide the weighted statewide average evapotranspiration by the weighted statewide average yield for a crop to determine the gallons of water per pound of food produced. Because it is impossible to irrigate so that all the water delivered to a farm is used for evapotranspiration, the calculated number was divided by 0.7.

We used the values from the report to calculate the amount of water used to produce the food for a specific daily diet. However, we multiplied each value by 0.7 before using them so that our numbers are conservative and represent only the water lost through evapotranspiration. We used a 2,200-calorie menu proposed by the U.S. Department of Agriculture Food, Nutrition and Consumer Service.

Breakfast was 1 medium orange, 1 banana, 1 bowl of dry cereal, 1 muffin, 2 pats of butter and 1/2 cup of milk, which totaled 130 gallons of water. Lunch was a taco salad and 2 ginger snaps which totaled 275 gallons of water. Dinner was chicken-vegetable stir-fry, cooked broccoli, 2 slices of bread, 2 pats of butter, and a fruit cup for a total of 220 gallons of water. Snacks consisted of 6 wheat crackers, 6 oz of yogurt and 1/2 cup of orange juice for a total of 83 gallons. The daily total was 708 gallons of water.

The daily amount of water used per person in a city home is variable, but 125 gallons/day is a typical value. For our scenario the city person uses a total of 833 gal/day of which 708 (85 percent) is for producing the food. The result that the percentage of water used to produce food is about the same as the percent of water delivered to agriculture is coincidental, but nevertheless illustrates the magnitude of the water delivered to agriculture that indirectly passes on to the urban dweller. ✦
Central Valley Crop Classification Processing Using Remote Sensing and GIS Technologies

By Jeff Milliken, Mariette Shin, David Hansen, Charles Johnson, Michael Sebhat, Joel Zander, USBR Mid Pacific Region
Central Valley Crop Classification Processing Using Remote Sensing and GIS Technologies

The U.S. Bureau of Reclamation and California Department of Water Resources are cooperating in a project to map crops and create crop reports using remote sensing and GIS technologies. The focus area is the Central Valley of California. This paper discusses procedures for Yolo and Kings counties, California, using ArcInfo, ArcView GIS, and ERDAS IMAGINE. This project is testing the application of procedures currently being used for crop classification in the Lower Colorado River Basin.

I. Introduction

This project is intended to demonstrate the applicability of crop mapping procedures used in the Lower Colorado River Basin for classifying crop types in the Central Valley of California. These procedures have achieved overall accuracies of approximately 93% (Congalton, et. al., 1998). The project also provides for technology transfer between the Mid-Pacific and the Lower Colorado Regions of the Bureau of Reclamation (BOR), and the California Department of Water Resources (CADWR).

Crop data and water use information is required for water contracts under the Central Valley Project Improvement Act (CVPIA) (Figure 1). Remote sensing and GIS can offer cost-effective means of providing more frequent crop/land cover data for short and long term planning. Two pilot areas in the Central Valley were identified for this project: Kings County and Yolo County (Figure 2). This paper summarizes the results of the Kings County classification. Yolo County work is presently being completed. Kings County, California is one of the largest crop producing counties in California. Some of the main crops grown here include tomatoes, cotton, safflower, corn, grain, alfalfa and rice. Of the 880,000 acres covered by Kings County, 600,000 acres are used for agriculture and 530,000 acres of that is used for field or vegetable crops (Figure 3) (CADWR, 1996).

II. Demonstration Project Methods

Imagery

For this demonstration, ground reference data collected by CADWR in the summer of 1996 was utilized in order to alleviate the need to collect additional field data. Satellite imagery was purchased from the USGS EROS Data Center to correspond as closely as possible with the 1996 field data collection dates. Because CADWR does not collect ground reference data for remote sensing procedures, crop-planting practices were also considered so that an image date containing as many mature crops as possible could be purchased. Knowledge of variability in planting and harvesting times for each crop is critical in the selection of image and field data collection dates during the year as spectrally unique "signatures" for crop classification are often dependent on the amount of vegetation cover. Crop calendars for Kings County were obtained to aid in choosing the best image dates. Ground reference data is required to understand unique relationships between the spectral signatures derived from the image data and crop types/conditions.
on the ground. However, CADWR ground reference data did not include crop condition (maturity, growth stage or the extent of vegetative ground cover) information so crop maturity was inferred from the amount of infrared reflectance in the image. This project focused on identifying only mature crop conditions. Landsat TM data acquired for this analysis was a July 8, 1996 scene, Path 42, Row 35 (World Reference System). Other considerations in image selection included percentage of cloud cover and overall quality of data. All satellite data and GIS coverages were projected into UTM Zone 10 (meters), NAD 27 datum with Clarke 1866 spheroid projection.

Field Border Database

For this project, we used the existing 1996 CADWR land use field border database attributed with crop types based on the 1996 CADWR survey (>11,000 fields). An example of a GIS field boundary database over Landsat TM imagery is presented in Figure 4. The data was converted from DXF into an Arc/Info polygon field border coverage.

Classification

LCRAS methods sample approximately 15% of the Lower Colorado Region agricultural fields to successfully identify crop types for the entire region. For this demonstration project, however, we had 100% of Kings County ground reference data from the 1996 CADWR survey. Therefore, we simulated future sampling requirements by selecting a subset of the CADWR data to represent a 15% ground reference sample. We first selected mature crops, as a remote sensing-based survey would utilize images coincident with mature crop conditions. In this instance, "mature" generally refers to crops that have a vegetative crown closure of greater than 30% to 30% (dependent on the nature of the crop). To determine immature versus mature crops, an unsupervised classification with 30 classes or clusters was run and analyzed to determine which fields were too immature (or fallow) to be tested with this procedure. An item called "Mature" was then added to the GIS field-border database and attributed as shown below:

0 – Minimal infrared response (immature or senescent crop, fallow)
1 – Irrigated crop (flooded, water)
2 – Dark agriculture (very wet mature crop)
3 – Medium to high infrared response (mature crop)
4 – Anomalous spectral response (probably mature crop- unusual spectral response).

Some Mature = 0 crop fields were included to generate signatures for fallow fields.

Next, an Arc Macro Language (AML) was used to complete a random stratified sample of approximately 15% of the crop fields based on crop type and the "Mature" attribute, for use as ground reference fields in the image classification process. This AML was also used to select (also random stratified) approximately 30 to 40% of the 15% sample to be reserved for an independent accuracy assessment (procedure used in LCRAS). The ground reference fields selected for image classification purposes were then buffered (inside) and used to mask the satellite imagery. Region growing algorithms (Woodcock, 1992) were then used to automatically generate spectral "regions" within the masked imagery for use in generating spectral signatures for the image classification process. These regions capture all within field spectral variation (Figures 5 and 6). Various region-growing parameters were tested to generate a reasonable signature set. These spectral regions were then converted to an ARC vector coverage and related back to the field border coverage database containing the crop type information. Spectral signatures were then automatically generated from the spectral regions in ERDAS using the ARC vector coverage as an Area of Interest (AOI) file (Figure 7). For further details on these processes see U.S.D.I. Bureau of Reclamation, 1997.

All unsupervised and supervised classifications were run in ERDAS Imagine 8.3 software. There were several evaluation and edit iterations of the generated signature file. The signature set was refined by including only those signatures with a pixel count of 12 or a standard deviation of less than or equal to 5.0 in all bands, and by visual inspection. Standard deviation cutoffs for optimal results may vary as a function of crop variability at the time of classification. Orchards, vineyards, semi-agricultural furrows and any other non-agricultural areas were not included in the training set signature files. Table 1 (Appendix) presents the crop classes sampled and used as input for the classification.

Signatures are automatically labeled in the ERDAS signature cell array from the Arc vector coverage (signature regions) cell array using ERDAS 8.3. Signature names were alphanumeric to include the field-id, the maturity value and the crop type for each signature region. Supervised classifications were then run on the training data set using a maximum likelihood classifier (ERDAS, 1997). The pixel crop-classifications were then summarized by field borders using the pixel classification and the field border coverage. The field received a crop label based on a plurality rule (i.e. - what most of the pixels within the field were classified as). This step often results in improved accuracies, as a given percentage of "noise" or error is commonly present within the classification at the pixel level.
After the classification was run, a crop "item" populated with the resulting classified crop code (crop label for the field) was joined to the field border coverage database.

Accuracy Assessment

A standard error matrix (Congalton, 1991) was constructed using the CADWR ground reference fields (not those reserved for accuracy assessment) to obtain an initial indication of accuracy. This information was used to refine the signature set (if needed) for a second iteration. Additional supervised classifications were then run and new error matrix tables were generated (Appendix – Table 2). Once an acceptable level of accuracy was reached, the independent fields reserved for accuracy assessment were utilized for a final accuracy matrix. Accuracies are reported based on acres of crops classed correctly.

III. Results

Three supervised classification iterations were completed. The overall accuracy was greater than 90% (Appendix – Table 2) in the first supervised classification. The results suggest that the greatest amount of error in the classifier is in small or low acreage fields. The mixed pixels caused by mixed conditions (i.e. road and crop) within a single pixel at the outer boundaries of the small fields may have resulted in field being mislabeled as these misclassed pixels will carry more weight in a small field with respect to the field labeling rules.

Constraints

Field Border Database

The project relied solely on the 1996 CADWR database; no additional field data was collected specifically for this project. Although this approach was a cost-effective means of testing the procedure, it created some limitations on the data analysis.

Although the imagery was purchased to match the mature stages of important crops, the field data collection time was not necessarily tied to crop maturity or spectral considerations. This is evident in the wide spectral variation observed in signatures for cotton and grains. More than one field data collection period and image classification may be required to reflect crop rotations. Additionally, the field labeling methodology assumes one crop type per field but in some instances the existing field border database showed a single field (polygon) that actually had more than one crop type present. These field borders would require additional boundaries to be added to reflect the multiple crop condition. Lastly, the absence of crop conditions or growth stage information in the CADWR field database makes some observed error difficult to explain.

Cotton Fields

Cotton represents the greatest crop acreage in Kings County. The classification correctly classed 99% of all cotton (Appendix – Table 2). However, cotton signatures were also responsible for the greatest errors of commission. This was probably due to the large amount of spectral variability within cotton fields (due to either defoliation from applied defoliant or salt stress). Signatures in these fields ranged from high infrared reflectance to fallow-like areas in a single field. An image date prior to defoliation may have alleviated some error caused by this relationship.

Frequency of Other Crops

Because there was inadequate signature representation of certain low frequency crops after the signature set was refined (e.g. sugar beets, Sudan grass, and asparagus), signatures for these types were manually generated. Other fields were too small in area to generate adequate signatures (e.g. melons and squash) but these types also have a very low relative acreage so do not represent significant error in final product.

IV. Conclusions

Considering the constraints of using field data not collected specifically for this methodology, and the possible discrepancy between field data collection dates and the purchased imagery, the classification results were still very good. Results indicate that greater than 90% classification accuracy can be expected using this methodology, sampling only about 15% of the agricultural fields. This methodology should prove useful in generating more frequent, cost-effective land use information.
Presently, the BOR is investigating coordination with other land cover mapping programs in the State of California (U.S.Forest Service / California Department of Fish and Forestry Protection Statewide Change Detection Program, California Department of Fish and Game Wetlands Mapping Program, and California Department Of Conservation Farmand Land Mapping Program). These types of cooperative initiatives are integral to providing timely data for short and long-range planning, developing standardized databases, reducing costs and redundancy in existing programs, and sharing technology between State and Federal agencies.

Acknowledgements

The authors would like to thank the Lower Colorado and Mid Pacific Regions of the Bureau of Reclamation and Tom Hawkins and Austin Eke of the California Department of Water Resources for support of this project.

V. Appendix

Table 1: Crop Classes Used in the Kings County, California Classification

<table>
<thead>
<tr>
<th>Crop Description</th>
<th>DWR Usage Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa Pasture</td>
<td>P1</td>
</tr>
<tr>
<td>Alfalfa Seed Crop</td>
<td>P1-S</td>
</tr>
<tr>
<td>Asparagus Seed</td>
<td>T2-S</td>
</tr>
<tr>
<td>Cole Crops</td>
<td>T4</td>
</tr>
<tr>
<td>Corn</td>
<td>F6</td>
</tr>
<tr>
<td>Corn/Cole Crop</td>
<td>F6/4</td>
</tr>
<tr>
<td>Cotton</td>
<td>F1</td>
</tr>
<tr>
<td>Dry beans</td>
<td>F10</td>
</tr>
<tr>
<td>Fallow</td>
<td>F-9</td>
</tr>
<tr>
<td>Grain and Hay</td>
<td>G</td>
</tr>
<tr>
<td>Grain/Broccoli</td>
<td>Gx22</td>
</tr>
<tr>
<td>Grain/Corn</td>
<td>GF6</td>
</tr>
<tr>
<td>Melons, Squash, Cucumber</td>
<td>T9</td>
</tr>
<tr>
<td>Melons/Cole Crop</td>
<td>T9/4</td>
</tr>
<tr>
<td>Melons/Dry beans</td>
<td>T9/F10</td>
</tr>
<tr>
<td>Miscellaneous Field Crop</td>
<td>F11</td>
</tr>
<tr>
<td>Mixed Pasture</td>
<td>P3</td>
</tr>
<tr>
<td>Onions-Garlic</td>
<td>T10</td>
</tr>
<tr>
<td>Safflower</td>
<td>F2</td>
</tr>
<tr>
<td>Sdadum</td>
<td>F8</td>
</tr>
<tr>
<td>Sugar Beets</td>
<td>F5</td>
</tr>
<tr>
<td>Sweet Potatoes</td>
<td>T13</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>T15</td>
</tr>
</tbody>
</table>

Table 2: Crop Classification Error Matrix for Kings County, California

<table>
<thead>
<tr>
<th>Sum of ACRES USAGE</th>
<th>CROP-LABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>P1</td>
</tr>
<tr>
<td>F10</td>
<td>P1-S</td>
</tr>
<tr>
<td>F2</td>
<td>T2-S</td>
</tr>
<tr>
<td>F5</td>
<td>T4</td>
</tr>
<tr>
<td>F6</td>
<td>F6/4</td>
</tr>
<tr>
<td>F8</td>
<td>F9</td>
</tr>
<tr>
<td>F-9</td>
<td>G</td>
</tr>
<tr>
<td>GF6</td>
<td>Gx22</td>
</tr>
<tr>
<td>Gx22</td>
<td>F1</td>
</tr>
<tr>
<td>G1-S</td>
<td>P3</td>
</tr>
<tr>
<td>T10</td>
<td>T10</td>
</tr>
<tr>
<td>T13</td>
<td>T13</td>
</tr>
<tr>
<td>T15</td>
<td>T15</td>
</tr>
<tr>
<td>T2-S</td>
<td>T2-S</td>
</tr>
<tr>
<td>T9</td>
<td>T9</td>
</tr>
<tr>
<td>T9/F10</td>
<td>T9/F10</td>
</tr>
<tr>
<td>Grand Total</td>
<td></td>
</tr>
</tbody>
</table>

### Central Valley Crop Classification Processing

#### California Water Plan Update 2005

| F1 - Cotton | 30801.05 | 8.30 | 1218.24 | 31.23 | 104.28 | 27.97 | 51.69 | 35.88 | 1790.62 | 279.28 | 71.69 | 101.22 | 14.14 | 152.12 | 184.74 | 4.94 | 51.00 | 34204.30 | 90.05 |
| F10 - Dry Beans | 1000 | 0.00 | 226.94 | 128.15 | | | | | | | | | | | | | |
| F11 - Misc. Field Crops | 226.94 | 90.05 | 102.70 | 102.70 | | | | | | | | | | | | | |
| F6 - Corn | 28.79 | 0.00 | 3572.52 | 240.78 | 90.83 | 118.32 | 7.71 | | | | | | | | | | | |
| F26 - Corn/Colt Crops | 0.00 | 0.00 | | | | | | | | | | | | | | | | |
| F6 - Sod | 70.98 | 100.00 | 70.98 | 70.98 | | | | | | | | | | | | | |
| E1 - Fallow | 51.00 | 100.00 | 1180.00 | 273.00 | | | | | | | | | | | | | |
| G1 - Grain and Hay | 6.72 | 100.00 | 128.00 | 608.00 | 10.30 | | | | | | | | | | | | | |
| G2 - Grain/Bean | 502.20 | 100.00 | 502.20 | 502.20 | | | | | | | | | | | | | |
| P1 - Alfalfa Pasture | 39.54 | 100.00 | 39.54 | 39.54 | | | | | | | | | | | | | |
| P5 - Alfalfa Seed/Crop | 146.98 | 100.00 | 146.98 | 146.98 | | | | | | | | | | | | | |
| P3 - Mixed Pasture | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | | | |
| F-F1 - Cotton/Corn | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | | | |
| T1 - Tomatoes | 189.44 | 100.00 | 189.44 | 189.44 | | | | | | | | | | | | | |
| T2 - Asparagus Seed | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | | | |
| T4 - Cole Crops | 1.98 | 100.00 | 1.98 | 1.98 | | | | | | | | | | | | | |
| T2-S - Asparagus Seed | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | | | |
| T4 - Cole Crops | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | | | |
| T4 - Cole Crops | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | | | |
| Grand Total | 31023.03 | 8.30 | 226.94 | 3420.97 | 102.70 | 5774.83 | 62.87 | 183.85 | 1791.83 | 7396.46 | 164.58 | 249.68 | 2152.41 | 2445.79 | 274.29 | 239.30 | 101.22 | 413.56 | 14.14 | 201.54 | 189.98 | 4.94 | 51.00 | 56494.21 | 90.05 |
| % error of omission | 99.28 | 0.00 | 100.00 | 100.00 | 68.80 | 0.00 | 43.28 | 77.12 | 92.32 | 0.00 | 100.00 | 92.40 | 92.40 | 0.00 | 68.80 | 0.00 | 89.11 | 0.00 | 24.52 | 0.00 | 0.00 | 0.00 | 90.58 |

**Note:** USAGE is the DWR classification from ground surveys. CROP-LABEL data is the result of the supervised classification.

### Figures

#### Figure 1: Central Valley Project

![Central Valley and CVP](http://gis.esri.com/library/userconf/proc99/proceed/papers/pap537/p537.htm)

- **The Central Valley and CVP**
- **CVP supplies about 6 million acre-feet to about 3 million acres of agriculture.**
- **The State Water**
Project supplies about 1 million acre-feet to agriculture

Figure 2: Yolo and Kings Counties

Demonstration Projects
Central Valley, CA
Figure 4: Field Boundaries over Landsat TM data
Figure 5: Spectrally Derived Signature Regions over TM Image
Central Valley Crop Classification Processing Using Remote Sensing and GIS Technologies

Figure 6: Spectral Regions in Single Field

Figure 7: Signature Generation Using ERDAS IMAGINE
VI. References


Central Valley Crop Classification Processing Using Remote Sensing and GIS Technologies


U.S. Bureau of Reclamation, Sacramento, CA 95835


CUP (Consumptive Use Program) Model
By Morteza Orang, Richard Snyder, and Scott Matyac, DWR and UC Davis
Consumptive Use Program Model

By Morteza N. Orang1, Richard L. Snyder2, J. Scott Matyac1

The California Department of Water Resources (DWR) and the University of California (UC) have developed a user-friendly Excel application program (CUP) to improve the dissemination of $K_c$ and crop evapotranspiration ($ET_c$) information to California growers and water purveyors. CUP computes reference evapotranspiration ($ET_o$) from monthly means of solar radiation, maximum and minimum temperature, dew point temperature, and wind speed using the daily Penman-Monteith equation. The program uses a curve fitting technique to derive one year of daily weather and $ET_o$ data from the monthly data. In addition, daily rainfall data are used to estimate bare soil evaporation as a function of mean of $ET_o$ and wetting frequency in days. A bare soil $K_c$ value is calculated to estimate the off-season evapotranspiration and as a baseline for in-season $K_c$ calculations. CUP accounts for the influence of orchard cover crops on $K_c$ values and for immaturity effects on $K_c$ values for tree and vine crops. Further, the program computes and applies all $ET_o$ and $K_c$ values on a daily basis to determine crop water requirements by month, by season, and by year.

Methodology

Reference Evapotranspiration ($ET_o$) Calculation

Reference evapotranspiration ($ET_o$) is estimated from daily weather data using a modified version of the Penman-Monteith equation (Walter and others 2000). The equation is:

$$ET_o = \frac{0.408 \Delta (R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34 \frac{u_2}{2})}$$

where $\Delta$ is the slope of the saturation vapor pressure at mean air temperature curve (kPa °C$^{-1}$), $R_n$ and $G$ are the net radiation and soil heat flux density in MJ m$^{-2}$d$^{-1}$; $\gamma$ is the psychrometric constant (kPa °C$^{-1}$), $T$ is the daily mean temperature (°C), $u_2$ is the mean wind speed in m s$^{-1}$, $e_s$ is the saturation vapor pressure (kPa) calculated from the mean air temperature (°C) for the day, and $e_a$ is the actual vapor pressure (kPa) calculated from the mean dew point temperature (°C) for the day. The coefficient 0.408 converts the $R_n - G$ term from MJ m$^{-2}$d$^{-1}$ to mm d$^{-1}$ and the coefficient 900 combines together several constants and converts units of the aerodynamic component to mm d$^{-1}$. The product 0.34 $u_2$, in the denominator, is an estimate of the ratio of the 0.12-m tall canopy surface resistance ($r_c=70$ s m$^{-1}$) to the aerodynamic resistance ($r_a=205/\nu^2$ s m$^{-1}$). It is assumed that the temperature, humidity, and wind speed are measured.

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2 University of California, Atmospheric Science, Davis, CA
between 1.5 m (5 ft) and 2.0 m (6.6 ft) above the grass-covered soil surface. If only temperature data are available, the Hargreaves-Samani equation is used. The equation may be written:

\[
ET_o = 0.0023 \left( T_c + 17.8 \right) R_a \left( T_d \right)^{1/2}
\]  

(2)

Where, \( T_c \) is the monthly mean temperature (degrees centigrade), \( R_a \) is the extraterrestrial solar radiation expressed in mm/month, and \( T_d \) is the difference between the mean minimum and mean maximum temperatures for the month (°C).

If pan data are input into the program, then the program automatically converts monthly pan evaporation data to \( ET_o \) estimates using the latest methodology. The new method in the CUP estimates \( ET_o \) from Epan data using a fetch value (that is, upwind distance of grass around the pan) without the need for wind speed and relative humidity data.

**Validation and Comparison of CUP with Other Methods**

Nine years of estimated daily \( ET_o \) data from CIMIS (California Irrigation Management Information System) at Davis, Calif., were used to validate our model predictions of \( ET_o \). Figure 1 compares daily mean \( ET_o \) estimates of CUP and CIMIS averaged over the period of the data set at Davis, Calif. The performance of the CUP was further evaluated at a humid location (Port Hueneme) and windy desert site (Bishop). Simulation of Evapotranspiration of Applied Water (SIMETAW) data are included. As seen in figures 1, 2, and 3, a close agreement between CIMIS-based estimates of \( ET_o \) and those of the CUP model exists. Davis is in the Central Valley, which is characterized by clear, hot, dry days with strong, cooling southwest winds during afternoons in the summer. Port Hueneme is in Ventura County with coastal cool, humid weather patterns. Bishop is influenced by a windy desert environment on the eastern side of the Sierra Nevada range.
Figure 2
Comparison of Estimated and Simulated Reference Evapotranspiration Data at Oceanside, California

- Averaged over 14 years of estimated data from CIMIS
- Averaged over 14 years of simulated data from SIMETAW
- Derived from CUP

Figure 3
Comparison of Daily ETo Estimates from CUP, SIMETAW, and CIMIS at Bishop, Calif.

- Averaged over 15 years of data from CIMIS
- Averaged over 15 years of simulated data
- Derived from CUP
Daily Weather Output Accuracy

One of objectives of the CUP model is to use a curve fitting technique to produce one year of daily weather data from 12 monthly mean values. Monthly mean values of measured weather data averaged over the period of the data set (1990–1998) from CIMIS in Davis were used in the model to derive one year of daily weather data. The weather data consist of $R_s$, $T_{\text{max}}$, $T_{\text{min}}$, wind speed, $T_{\text{dew}}$, and rainfall. The weather data derived by CUP were compared with the measured and simulated data from CIMIS and SIMETAW, respectively. Results in figures 4, 5, and 6 showed that $R_s$, $T_{\text{max}}$, and rainfall values predicted from CUP were well correlated with those values obtained from CIMIS and SIMETAW. The performance of the CUP was further evaluated at a humid location and windy desert site. In all locations, CUP correlated very well with CIMIS and SIMETAW. Similar results were also observed for $T_{\text{min}}$, wind speed, and $T_{\text{dew}}$ data in other locations.

![Comparison of Measured and Predicted Daily Solar Radiation Data at Davis, Calif.](image-url)

Figure 4
Comparison of Measured and Predicted Daily Solar Radiation Data at Davis, Calif.
Figure 5
Comparison of Measured and Predicted Daily Air Maximum Temperature Data at Davis, Calif.

- Averaged over 9 years of measured data from CIMIS
- Averaged over 9 years of simulated data from SIMETAW
- Derived from CUP

Figure 6
Comparison of Monthly Total Rainfall Values from Three Different Methods at Davis, Calif.

- Derived from CUP
- Simulated by SIMETAW
- Obtained from CIMIS
Worksheets

CUP has 19 Excel worksheets. The first eight worksheets are ‘Disclaimer,’ ‘HelpAbout,’ ‘About Cup,’ ‘HELP,’ ‘ETo Zones Map,’ ‘ETo Zones,’ ‘Weather Input,’ and ‘Input_Output.’ ‘HelpAbout’ provides information about the program. ‘About CUP’ explains the program. ‘HELP’ explains the various components of the program and provides step-by-step instructions for inputting data into the program. ‘ETo Zones’ contains a map showing 18 zones of similar ETo rates for California. The ‘Weather Input’ worksheet is used to input monthly mean weather or Ep data to estimate ETo (or monthly mean ETo data directly) for estimating crop evapotranspiration (ETc). If the solar radiation, temperature, humidity, and wind speed data are input, then the Penman-Montieth equation is used to calculate ETo. If only temperature data are input into the table, then the Hargreaves-Samani equation is used to calculate ETo. If pan data are input, the program automatically estimates daily ETo rates using a fetch value (that is, upwind distance of grass around the pan). ETo and crop data are entered into the ‘Input_Output’ worksheet, which then displays the summary of inputs and monthly and seasonal outputs. The ‘Crop References’ worksheet contains a list of crops, crop numbers, estimated growth date, and Kc information. ‘Calculation’ worksheet shows all of the growth date and Kc as well as the daily calculations of ETo, Kc and ETc for each of the growth periods. ‘Weather Output’ provides one year of daily solar radiation, maximum and minimum temperature, wind speed, dew point temperature, and rainfall data. CUP also outputs one year of daily calculated crop coefficients, ETo, and ETc data by crop in the ‘Daily ETc-Output’ worksheet. ‘Monthly Output’ provides monthly total values of ETo, ETc, and rainfall during the growing season and off-season.

The ‘Kc Chart’ worksheet shows a plot of the calculated seasonal crop coefficients with colored lines representing each growth period. ‘ETo Chart’ worksheet plots daily ETo with different colored lines for each growth period. The ‘ETo,ETc Chart’ provides a bar graph of ETo and ETc totals by month during the growing season for the current crop information. There are also summary worksheets for Kc values, ETo and ETc. After data entry, the current crop information and calculated Kc data in the ‘Input_Output’ worksheet can be printed to one row in the ‘Summary of Kc’ worksheet. ETo data are printed to ‘Summary of ETo’, and ETc data are printed to ‘Summary of ETc.’

Input_Output Worksheet

Crop information is entered into cells on the left-hand side of the ‘Input_Output’ worksheet. To use monthly mean weather, raw ETo and pan data, 88 is input into the California ETo Zone number. Next a crop number is entered into the Crop Number cell. CUP provides a list of crops and crop numbers in the ‘Crop References’ worksheet. That worksheet also contains the percentage of the season to various growth dates (explained later), Kc values at critical growth points, and sample start and end dates for the season.

Note that the crop numbers have one digit to the left and two digits to the right of a decimal point. The single digit identifies the crop type, and the double digit identifies the crop. When a crop is selected, the growth, Kc, and default start-end information are automatically used for the calculations. The start date corresponds to planting for field and row crops and to leaf-out date for tree and vine crops. Non-deciduous trees, turfgrass, and pasture crops start on January 1 and end on December 31. If different from the default values, the start and end dates can be changed in the ‘Input_Output’ worksheet.
The initial $K_c$ value for most crops depends on wetting frequency from rainfall and/or irrigation. As the canopy shading increases, the contribution of soil evaporation to $ET_c$ decreases while the contribution of transpiration increases. In the ‘Input_Output’ worksheet, the rainfall frequency during early growth is input to determine a $K_c$ for near bare soil evaporation. Similarly, the irrigation frequency is entered and a $K_c$ determined for near bare-soil evaporation during initial growth of field and row crops. CUP compares $K_c$ values from the ‘Crop References’ worksheet with those based on rainfall and irrigation frequency and selects the largest of the three for use in calculating $ET_c$. If no rainfall or irrigation frequency is entered, the $K_c$ from the A-B column in the ‘Crop References’ worksheet is used as the initial growth $K_c$. The starting $K_c$ for type-2 crops (for example, turfgrass and pasture) and for type-4 crops (for example, subtropical orchards) is not affected by the irrigation or rainfall frequency entries.

Cover crops affect $ET_c$ rates, and CUP accounts for the contributions. The cover crop start and end dates are input into cells under the “Enter 1st Cover Crop (day/mon).” Because some crops have cover crops in spring and fall but not in the summer, a second set of cover crop dates can be input under “Enter 2nd Cover Crop (day/mon)”. During a period with a cover crop, the value 0.35 is added to the “clean cultivated” $K_c$ value. However, the $K_c$ is not allowed to exceed 1.15 or to fall below 0.90.

The right-hand side of the ‘Input_Output’ worksheet shows the weighted mean $K_c$, $ET_o$, $ET_c$, and seasonal $ET_c$ values by month for the selected crop and input information. The daily mean $ET_o$ rates by month are also shown below the other data. Below that set of cells, there are “Copy/Paste” and “Delete” buttons. When the Copy/Paste button is pressed, results of the calculations are sent to ‘Summary $ET_o$,’ ‘Summary $K_c$,’ and ‘Summary $ET_c$’ worksheets. The Delete button clears all entries from the summary worksheets. To retain all of the data entries, save the CUP file as an Excel workbook with a different name. To save only the summary sheets, with the summary sheet displayed, save as a tab or comma delimited file. After saving the desired output data, click the Delete button to erase data from the summary worksheets.

**Calculation Worksheet**

The ‘Calculation’ worksheet shows the selected and input data as well as critical dates for growth and cover crops and the daily calculations of $ET_o$, $K_c$ and $ET_c$ by the growth stages. The main factors affecting the difference between $ET_o$ and $ET_c$ are (1) light absorption by the canopy, (2) canopy roughness, which affects turbulence, (3) crop physiology, (4) leaf age, and (5) surface wetness. When not limited by water availability, both transpiration and evaporation are limited by the availability of energy to vaporize water. Therefore, for unstressed crops, solar radiation (or light) interception by the foliage and soil mainly affect the $ET_c$ rate.

As field and row crops grow, the canopy cover, light interception, and the ratio of transpiration ($T$) to $ET$ increases until most of the $ET$ comes from $T$ and evaporation ($E$) is a minor component. The $K_c$ increases with canopy cover until reaching about 75 percent cover. For tree and vine crops the peak $K_c$ is reached when the canopy has reached about 70 percent ground cover. The difference between the crop types is that the light interception is higher for the taller crops.
Field and Row Crop $K_c$ Values

Field and row crop $K_c$ values are calculated using a method similar to that described by Doorenbos and Pruitt (1977). A generalized curve is shown in Figure 7. In their method, the season is separated into initial (date A-B), rapid (date B-C), midseason (date C-D), and late season (date D-E) growth periods. $K_c$ values are denoted $K_cA$, $K_cB$, $K_cC$, $K_cD$ and $K_cE$ at the ends of the A, B, C, D, and E growth dates, respectively. During initial growth, the $K_c$ values are at a constant value, so $K_cA = K_cB$. During the rapid growth period, when the canopy increases from about 10 percent to 75 percent ground cover, the $K_c$ value increases linearly from $K_cB$ to $K_cC$. The $K_c$ values are also at a constant value during midseason, so $K_cC = K_cD$. During late-season, the $K_c$ values decrease linearly from $K_cD$ to $K_cE$ at the end of the season.

Figure 7
Hypothetical Crop Coefficient Curve for Field and Row Crops Using Percentage of Season to Delineate Growth Dates

The dashed line is for fresh market crops with no late-season $K_c$ drop (that is, there is no date D)
Doorenbos and Pruitt (1977) provides estimated number of days for each of the four growth periods to help identify the end dates of growth periods. However, because there are climate and varietal differences and because it is difficult for growers to know when the inflection points occur, irrigators often find this confusing. To simplify this problem, percentages of the season from planting to each inflection point rather than days in growth periods are used (Figure 7). Irrigation planners need only enter the planting and end dates. The intermediate dates are determined from the percentages, which are easily stored in a computer program.

During initial growth of field and row crops, the default $K_c$ value ($K_{c1}$) is used for $K_cA$ and $K_cB$ unless it is overridden by entering a $K_c$ based on rainfall or irrigation frequency. If a soil wetting based $K_{c1}$ is desired, the irrigation or rainfall frequency is entered in the ‘Input_Output’ worksheet.

The values for $K_cC = K_cD$ depend on the difference in (1) light interception, (2) crop morphology effects on turbulence, and (3) physiological differences between the crop and reference crop. Some field crops are harvested before senescence, and there is no late season drop in $K_c$ (for example, silage corn and fresh market tomatoes). Relatively constant annual $K_c$ values are possible for some crops (for example, turfgrass and pasture) with little loss in accuracy.

**Deciduous Tree and Vine Crop $K_c$ Values**

Deciduous tree and vine crops, without a cover crop, have $K_c$ curves that are similar to field and row crops but without the initial growth period (Figure 8). Default $K_{cB}$, $K_{cC} = K_{cD} = K_{c2}$ and $K_{cE} = K_{c3}$ values are given in the ‘Crop References’ worksheet of the CUP. The season begins with rapid growth at leaf out when the $K_c$ increases from $K_{cB}$ to $K_{cC}$. The midseason period begins at approximately 70 percent ground cover. Then, unless the crop is immature, the $K_c$ is fixed between dates C and D, which corresponds to the onset of senescence. For immature crops, the canopy cover may be less than 70 percent during the midseason period. If so, the $K_c$ will increase from $K_{cC}$ up to the $K_{cD}$ as the canopy cover increases, so the CUP program accounts for $K_c$ changes of immature tree and vine crops. During late season, the $K_c$ decreases from $K_{cD}$ to $K_{cE}$, which occurs when the transpiration is near zero.
Correcting $K_cB$ for Soil Evaporation

Initially, the $K_c$ value for deciduous trees and vines ($K_cB$) is selected from a table of default values. However, the ET is mainly soil evaporation at leaf out, so CUP contains the methodology to determine a corrected $K_cB$, based on the bare soil evaporation.

Correcting for Cover Crops

With a cover crop, the $K_c$ values for deciduous trees and vines are higher. When a cover crop is present, 0.35 is added to the clean-cultivated $K_c$. However, the $K_c$ is not allowed to exceed 1.15 or to fall below 0.90. CUP allows the beginning and end dates to be entered for two periods when a cover crop is present in an orchard or vineyard.
Immature Trees and Vines

Immature deciduous tree and vine crops use less water than mature crops. The following equation is used to adjust the mature $K_c$ values ($K_{cm}$) as a function of percentage ground cover ($C_g$).

$$\text{If } \sqrt{\sin \left( \frac{C_g \pi}{70} \right)} \geq 1.0 \text{ then } K_c = K_{cm} \text{ or else } K_c = K_{cm} \sqrt{\sin \left( \frac{C_g \pi}{70} \right)}$$

(3)

Subtropical Orchards

For mature subtropical orchards (for example, citrus), using a fixed $K_c$ during the season provides acceptable $ET_c$ estimates. However, if higher, the bare soil $K_c$ is used for the orchard $K_c$. For an immature orchard, the mature $K_c$ values ($K_{cm}$) are adjusted for their percentage ground cover ($C_g$) using the following criteria.

$$\text{If } \sqrt{\sin \left( \frac{C_g \pi}{70} \right)} \geq 1.0 \text{ then } K_c = K_{cm} \text{ or else } K_c = K_{cm} \sqrt{\sin \left( \frac{C_g \pi}{70} \right)}$$

(4)

Field Crops and Landscape Covers with Fixed $K_c$ Values

Some field crops and landscape plants (type-2 crops) have fixed $K_c$ values all year. However, if the significant rainfall frequency is sufficient to have a higher $K_c$ for bare soil than for the selected crop, then the higher bare soil $K_c$ should be used. CUP permits entry of monthly mean rainfall frequency data. If entered, daily $K_c$ values for bare soil evaporation are computed for the entire year. The higher of the fixed crop $K_c$ or the bare soil $K_c$ is used to estimate $ET_c$ for the crop. If no rainfall frequency data are entered, then the fixed crop $K_c$ is used.

Estimating Bare Soil $K_c$ Values

A soil evaporation $K_c$ value, based on $ET_o$ and rainfall frequency is needed as a minimum (baseline) for estimating $ET_c$. It is also useful to determine the $K_c$ value during initial growth of field and row crops ($K_{c1} = K_{cA} = K_{cB}$), based on irrigation frequency, and the starting $K_c$ for deciduous tree and vine crops ($K_{c1} = K_{cB}$). The $K_c$ values used to estimate bare soil evaporation are based on a two-stage soil evaporation method reported by Stroonsnijder (1987) and refined by Snyder and others (2000). The method provides a $K_c$ values as a function of $ET_o$ rate and wetting frequency that are similar to those published in Doorenbos and Pruitt (1977).

If the mean monthly weather and $ET_o$ data are input into the ‘Weather Input’ worksheet, including the number of significant rainy days per month, CUP calculates a baseline soil evaporation curve. Daily precipitation is considered significant when $P_s > 2 \times ET_o$. Whenever, the $K_c$ for bare soil evaporation is bigger than the $K_c$ based on table or calculated $K_c$ values, the higher $K_c$ value is used.
Extra Features of CUP

The CUP application program uses MS Excel software as a tool to help water agencies, engineers, consultants, educators, and growers obtain accurate estimates of crop water requirement information from monthly mean data. The program takes input weather data and estimates historical means of reference evapotranspiration ($ET_o$) using the Penman-Montieth equation. If only temperature data are available, the Hargreaves-Samani equation is used. CUP also converts monthly pan evaporation data to $ET_o$ estimates using the latest methodology. In addition, CUP estimates the annual trend in daily $ET_o$ and weather data. In the past, only monthly, biweekly, or weekly data were available in the literature; daily data from CUP improves the $ET_o$ estimation. Alternatively, CUP can select monthly $ET_o$ values from the California $ET_o$ map, and it can estimate $ET_o$ from class ‘A’ pan evaporation using the latest conversion methods. The program helps users determine improved crop coefficient ($K_c$) values for estimating crop evapotranspiration ($ET_c$). Rather than using only linear estimates of the $K_c$ values for various growth stages, CUP accounts for differences in soil evaporation to refine the early season $K_c$ values. CUP can be used as a tool for teaching and conducting research. In addition, the application outputs a wide range of tables and charts useful for irrigation planning. CUP’s input and output data are in both English and metric units.

More information on CUP is available at DWR’s Web site: www.waterplan.water.ca.gov/landwateruse/wateruse/Ag/wuagricultural.htm

References


Evaporation Research — A Review and Interpretation
By C.M. Burt, A.J. Mutziger, R.G. Allen, and T.A. Howell
Evaporation Research – A Review and Interpretation

C.M. Burt¹, A.J Mutziger², R.G. Allen³ and T.A. Howell⁴

1.1 Background

Evapotranspiration (ET) represents the major consumptive use of irrigation water and rainfall on agricultural land. There has been considerable research to define ET for various crops and to understand the relationship between ET and crop yield. Because transpiration (T) is the portion of ET that flows through the plant system, it is the main component of ET that impacts the ET – yield relationship. Nevertheless, the evaporation (E) component within and outside the crop growing season can be a significant component of the total ET. Given the increased competition for water in the state, it is important to search for new ways to conserve water and/or to use it more efficiently. This paper examines the factors that affect the E component, and the relative percentage of E in the overall ET balance.

Most of the literature reviewed provided information in a format that did not lend itself to direct comparison with other literature results. Therefore, within this paper various data have been re-arranged and organized so that results can be compared. However, because of the sheer volume of work required, the authors have not attempted to re-create figures and tables found in the literature; these were simply scanned into the document.

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**1.1.1 What Falls under "Evaporation"**

Evaporation in a soil-plant-atmosphere system occurs from each of the system components. Evaporation from the soil is effected by soil water content, type, and tilth, the presence or absence of surface mulches, and the environmental conditions being imposed on the soil. Evaporation from the plant surfaces is effected by the plant canopy water storage capacity, the length of time that rain or irrigation water is impacting the plants, and the environmental conditions imposed on the plants. Evaporation from the atmosphere (sprinkler droplet evaporation) is associated with sprinkler irrigation methods and is the amount of applied water that does not reach the soil-plant system, but does not include drift losses. It is affected by droplet size, relative humidity, angle and distance of droplet travel, and water temperature. Transpiration (T) is a specific form of evaporation in which water from plant tissue is vaporized and removed to the atmosphere primarily through the plant stomata. The combined water that is transferred to the atmosphere through evaporation (E) and transpiration (T) processes is known as evapotranspiration.

**1.1.2 Evaporation Equations**

In general, evaporation has been estimated in research using four approaches:

1. Water balance method
2. Energy balance method
3. Coupled water and energy balance methods
4. Semi-empirical and empirical methods

### 1.1.2.1 Water Balance Method

The general water balance equation for determining evaporative loss from soil, foliage, and sprinkler spray and transpiration is:

\[
E + T = P + I + \Delta S - D - R
\]  

(1)

where E is evaporation, T is transpiration, P is precipitation, I is irrigation, \(\Delta S\) is change in soil water storage for the medium of interest, and D and R are drainage or runoff losses for the medium of interest. The units are water depth over the evaluated time frame (e.g. mm d\(^{-1}\)).

In the soil medium, E can be separated from evapotranspiration (ET) by either measuring E with microlysimeters, by measuring T with stem flow gauges, or by having no plants in the system.

### 1.1.2.2 Energy Balance Method

The general surface energy balance equation is given by:
\[ LE = ET = R_N - G - H \]  \hspace{1cm} (2)

where \( LE \) is the outgoing latent heat flux from evaporation and transpiration, \( R_N \) is the incoming net solar radiation, \( G \) is the soil heat flux, and \( H \) is the sensible heat flux above the canopy. The units for these terms are commonly watts m\(^{-2}\) (1mm of ET d\(^{-1}\) = 28.36 watts m\(^{-2}\)). The equation components can be measured remotely with sensing technologies or on the ground with Bowen Ratio or Eddy Correlation equipment. Considerable work is being done with remote sensing to enable accurate estimation of regional water losses; that work is in the development stages and cannot provide a detailed breakdown of evaporation and transpiration.

A variety of radiation-temperature based energy balance models (Jensen and Haise, 1963; Priestley and Taylor, 1972; Jensen et al., 1990) have been developed. But over the past 20 years the emphasis has been on the Penman method, modified Penman methods, and the Penman-Monteith methods. These utilize the weather components of solar radiation, relative humidity, wind run, and air temperature to estimate a reference crop ET. When combined with a crop coefficient, the reference crop ET can be used to estimate crop ET. The most recent version of such methods is referred to in this paper as the “FAO - 56 Method”, which is the procedure described by Allen et al. (1998).

One of the mass transfer models evaluated, Cupid-DPEVAP (Thompson et al., 1993a, 1993b, 1997), determines evaporation from wet foliage with an energy balance equation that uses leaf storage capacity and the depth of the intercepted water. The DPEVAP model and a similar model by Kincaid and Longley (1989) combine heat transfer and diffusion theory in an energy balance to estimate sprinkler evaporation.

### 1.1.2.3 Coupled Water and Energy Balance Methods

Coupled water and energy balance methods tend to be complex and require many field-measured and sensitive parameters, making them impractical for large scale estimation studies.

### 1.1.2.4 Semi-empirical and Empirical Methods

These methods apply only to bare soil evaporation. Several semi-empirical and empirical relationships for \( E \) have been developed, but they are very site specific (e.g., non-transferable). One such method presented in Stroosnijder (1987), Gallardo et al. (1996), and Snyder et al. (2000) is a variation on the classic two-stage evaporation model presented by Ritchie (1972). In both methods, Stage 1 evaporation from the soil is limited only by the energy input. For Stage 2, Ritchie (1972) identified a semi-empirical evaporation equation that was a function of the square root of time. The more recent papers found a good semi-empirical relationship between cumulative bare soil evaporation and cumulative reference evapotranspiration.
1.2 Soil Evaporation

1.2.1 FAO-56 Method and Modifications

1.2.1.1 Single and Dual Crop Coefficient in FAO - 56

The Food and Agriculture Organization of the United Nations (FAO) Irrigation and Drainage paper 56 (Allen et al., 1998) provides a good summary of how crop coefficients in conjunction with reference ET measurements are used to determine ET for the crop (ET$_c$) or estimate the partitioning of ET into E and T. In general, the single crop coefficient (K$_c$) is used to define ET$_c$:

$$ET_c = K_c ET_o$$  \hspace{1cm} (3)

where ET$_o$ is the ET from a pristine reference grass as defined in the FAO - 56 (Allen et al, 1998).

The K$_c$ term in equation 3 can be replaced as a dual crop coefficient to partition E and T:

$$K_c = K_s K_{cb} + K_e$$  \hspace{1cm} (4)

where K$_s$ is the reduction coefficient for crop stress, K$_{cb}$ is the basal crop coefficient, or the ratio of ET$_c$ to ET$_o$ for dry surface soil conditions in which the water content in the underlying soil does not limit the full plant transpiration needs, and K$_e$ is a soil water evaporation coefficient. In general, transpiration is obtained by multiplying the product of K$_c$ and K$_{cb}$ by ET$_o$ and evaporation is computed by multiplying K$_e$ by ET$_o$. Details such as upper limits to the coefficients are discussed in Allen et al (1998).

1.2.1.2 Comparison of FAO - 56 Kr Against Measured Kr of Three Soil Types from One Source

FAO - 56 gives the following description of the evaporation reduction coefficient, Kr:

Evaporation from the exposed soil can be assumed to take place in two stages: an energy limiting stage, and a falling rate stage. When the soil surface is wet, Kr is 1. When the water content in the upper soil becomes limiting, Kr decreases and becomes zero when the total amount of water that can be evaporated from the topsoil is depleted.

Stage 1 is assumed to exist until the soil surface color lightens due to the loss of moisture. Figure 3-1 graphically presents a general case of the two stage relationship. It illustrates Figure 38 of Allen et al (1998).
Figure 3-1. Cumulative evaporation depth (De) or volumetric soil water content versus the FAO - 56 soil evaporation reduction coefficient (Kr) (Allen et al, 1998). Note that FAO - 56 assumes that the total evaporable water (TEW) has been depleted when the volumetric soil water content is reduced to half of the permanent wilting point water content for the soil.

Chanzy and Bruckler (1993) presented the measured Kr relationship for three bare soils in Avignon, France (Figure 3-2). They used soil samples to compute the volumetric soil water content in the first 0.05 m of soil and the amount of soil evaporation (E) that was the result of the potential soil evaporation (Ep) for a given day as defined by Penman (1948). The evaporation reduction coefficient is then given by Kr = E/Ep.
Figure 3-2. Ratio of daily bare soil evaporation (Ed) to daily potential soil evaporation (Epd) as related to the volumetric water content in the first 5 cm of soil for 3 different soil types, 1 range of Epd, and for 2 ranges of average daily wind speed (Uad). Chanzy and Bruckler (1993) (Note: Since higher wind speed results in higher evaporation, it appears that the legend definitions for the dot and circle symbols of this figure [Figure 8 from Chanzy and Bruckler, 1993] need to be interchanged).

Since the specific loam, silty clay loam, and clay properties for the Avignon soils presented in Chanzy and Bruckler (1993) were not known, we used soil property ranges given in FAO - 56 (Table 3-1) to define average FAO - 56 Kr relationship for these soil types (Table 3-2).

Table 3-1. Range of FAO - 56 parameters for defining the evaporation reduction coefficient (Kr) relationship for loam, silty clay loam, and clay soils (Allen et al, 1998).

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>FAO - 56 $\theta_{FC}$ Range (m$^3$/m$^3$ Soil)</th>
<th>FAO - 56 $\theta_{WP}$ Range (m$^3$/m$^3$)</th>
<th>FAO - 56 Range of Plant Available Water, $\theta_{FC} - \theta_{WP}$ (m$^3$/m$^3$)</th>
<th>FAO - 56 Stage 1 REW C Range (mm)</th>
<th>FAO - 56 Stage 1 &amp; 2 TEW D Range (Ze = 0.1m) E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam</td>
<td>0.20 - 0.30</td>
<td>0.07 - 0.17</td>
<td>0.13 - 0.18</td>
<td>8-10</td>
<td>16-22</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>0.30 - 0.37</td>
<td>0.17 - 0.24</td>
<td>0.13 - 0.18</td>
<td>8-11</td>
<td>22-27</td>
</tr>
<tr>
<td>Clay</td>
<td>0.32 - 0.40</td>
<td>0.20 - 0.24</td>
<td>0.12 - 0.20</td>
<td>8-12</td>
<td>22-29</td>
</tr>
</tbody>
</table>

A $\theta_{FC}$ is the volumetric water content of the soil at field capacity
B $\theta_{WP}$ is the volumetric water content of the soil at wilting point
C REW - When the soil is at its peak water content, this is the amount of readily evaporable water
D TEW - When the soil is at its peak water content, this is the amount of total evaporable water
E Ze - Depth of surface soil layer that is subject to drying by way of evaporation.
Table 3-2. FAO - 56 parameters selected by the authors to determine the average evaporation reduction coefficient (Kr) for loam, silty clay loam, and clay soils.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Chosen $\theta_{FC}^A$ to Obtain Avg Avail. Water B (m$^3$/m$^3$ Soil)</th>
<th>Chosen $\theta_{WP}^C$ to Obtain Avg Avail. Water B (m$^3$/m$^3$)</th>
<th>FAO - 56 Avg. Plant Available Water $\theta_{FC} - \theta_{WP}$ (m$^3$/m$^3$)</th>
<th>Avg. FAO - 56 REW D (mm)</th>
<th>Computed TEW E $\theta_{FC} - 0.5\theta_{WP}$ G (m$^3$/m$^3$)</th>
<th>Final Water Content $\theta_{FC} -$ TEW (m$^3$/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam</td>
<td>0.263</td>
<td>0.108</td>
<td>0.155</td>
<td>9.0</td>
<td>20.9</td>
<td>0.209</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>0.350</td>
<td>0.195</td>
<td>0.155</td>
<td>9.5</td>
<td>25.3</td>
<td>0.253</td>
</tr>
<tr>
<td>Clay</td>
<td>0.375</td>
<td>0.215</td>
<td>0.160</td>
<td>10.0</td>
<td>26.8</td>
<td>0.268</td>
</tr>
</tbody>
</table>

A $\theta_{FC}$ is the volumetric water content of the soil at field capacity
B ITRC chosen $\theta_{FC}$ and $\theta_{WP}$ were as near to their mean value as possible while still yielding the average possible FAO - 56 available water for the given soil type
C $\theta_{WP}$ is the volumetric water content of the soil at wilting point
D REW - When the soil is at its peak water content, this is the depth of readily evaporable water
E TEW - When the soil is at its peak water content, this is the depth of total evaporable water
F Ze - Depth of surface soil layer that is subject to drying by way of evaporation
G FAO - 56 assumes the TEW for a soil has been depleted when the volumetric soil water content is reduced to half of the $\theta_{WP}$ for the soil.

Figures 3-3, 3-4, and 3-5 illustrate the Kr relationships that were measured (squares and diamonds) by Chanzy and Bruckler (1993) and the average relationships as defined by the authors (“ITRC”) using FAO - 56 (circles and triangles) for the three soil types. The data point in the middle of the ITRC-defined average falling-rate-stage of each Kr relationship is the wilting point of the soil.
Crop Water Use

Figure 3-3. Comparison of the measured loam (Avignon, France) Kr relationships derived from Chanzy and Bruckler (1993), against the Kr relationship of an average loam soil using FAO - 56.

Figure 3-4. Comparison of the measured silty clay loam (Avignon, France) Kr relationships derived from Chanzy and Bruckler (1993), against the Kr relationship of an average silty clay loam using FAO - 56.
Figure 3-5. Comparison of the measured clay (Avignon, France) Kr relationships derived from Chanzy and Bruckler (1993), against the Kr relationship of an average clay using FAO - 56.

The key points from this section are:

1. For all 3 soil types, the measured (Chanzy and Bruckler, 1993) Kr relationships had nearly identical falling rates.
2. For all 3 soil types, the average Kr relationships from FAO - 56 had similar falling rates to the measured rates.
3. The average Kr relationships from FAO - 56 are shifted relative to the measured Kr relationships, particularly for the clay. This is an indication that the readily evaporable water (REW) for the Avignon, France soils was somewhat different from the average FAO - 56 REW values for that soil.
4. Considering that the FAO - 56 computation was done without knowing the soil properties for the 3 soil types presented in Chanzy and Bruckler (1993), the measured and average Kr relationships using FAO - 56 are fairly close.
5. “Average" FAO - 56 soil textures used to define the Kr relationship will give reasonably accurate results.
6. FAO - 56 suggests that the depth of the surface soil layer that is subject to evaporation (Ze) may be around 0.1 to 0.15 m. Following this, the average Kr relationships for the soils were defined by the authors using a Ze of 0.1m. It is interesting to note that the average Kr relationships for the three soils are similar to the measured relationships even though the measured evaporation by Chanzy and Bruckler was determined by evaluating only the top 0.05m of soil.
1.2.1.3 FAO - 56 Modifications

Allen et al (1998) presented the FAO Penman-Monteith equation and crop coefficient procedure that computes both the E and T components of crop ET. The soil evaporation computations used the relationship described in the previous section. For this study of evaporation on California’s irrigated lands, several modifications were made to the FAO - 56 procedures. They were:

1. Partitioning the evaporation into precipitation and irrigation origins. Evaporation on the day of a precipitation event, and the days following that event, was designated as evaporation from precipitation until the available precipitation water was used.

2. The initial basal crop coefficient (Kcb) represents evaporation. Initial Kcb values range from 0.15 – 0.35. As a plant emerges or blooms, the evaporation portion of Kcb declines. The partitioning procedure between evaporation and transpiration for the initial Kcb is described in section B-1.2 of Appendix B.

3. Evaporation from wet plant surfaces was computed for 2 days per sprinkler application. This is because most sprinklers in California are hand move sprinklers, which typically wet one area for 2 days. The evaporation for those 2 days was set as the difference in ETo between a stomatal resistance of 0 s/m and 70 s/m.

4. A 3rd stage of evaporation was included, to account for evaporation from open cracks on cracking clay soils and reduced vapor diffusion on some silt loam soils.

1.2.1.4 Comparison of FAO-56 ET Against Measured ET from Multiple Sources

The FAO - 56 simulated evaporation was compared against measured evaporation for 6 lysimeter and 1 Bowen Ratio measured bare or near bare soil evaporation data sets. Detailed information about each data set is found in Appendix E. Three of the lysimeter data sets are from Bushland, TX (Howell et al., 1995), one is from Davis, CA (Parlange et al., 1992), one is from Temple, TX (Ritchie, 1972), and one is from Kimberly, ID (Wright, 2001 pers. comm.). The Bowen Ratio data set was from Farahani and Bausch (1995). These data sets were selected because they appeared to have been collected with excellent quality controls.

Another FAO - 56 simulation was run to compare data from Farahani and Bausch (1995) that used 12-hour measurements with Bowen Ratio equipment as an estimate of the daily evaporation. The FAO - 56 simulation results matched those of the 5 lysimeter studies more closely than they did those of the Bowen Ratio study. In the absence of other extended period evaporation measurements that used Bowen Ratio equipment to compare against, the Farahani and Bausch (1995) data are listed but not included in Table 3-3 with the averages for the lysimeter studies.
Table 3-3. Comparison of FAO - 56 simulated evaporation against various field measurements of evaporation.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Year measurements were collected</td>
<td>1969</td>
<td>1990</td>
<td>1989</td>
<td>1991</td>
<td>1992</td>
<td>1993</td>
</tr>
<tr>
<td>Measurement method</td>
<td>Lysimeter</td>
<td>Lysimeter</td>
<td>Lysimeter</td>
<td>Lysimeter</td>
<td>Lysimeter</td>
<td>Bowen Ratio Equipment</td>
</tr>
<tr>
<td># of days from start to end of the evaluated period</td>
<td>12</td>
<td>10</td>
<td>31</td>
<td>41</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>Rain or irrigation during the period (mm)</td>
<td>48.4</td>
<td>18.1</td>
<td>74.0</td>
<td>104.8</td>
<td>95.7</td>
<td>56.1</td>
</tr>
<tr>
<td>Measured cumulative bare soil evaporation (mm)</td>
<td>24.2</td>
<td>16.8</td>
<td>52.8</td>
<td>93.7</td>
<td>81.2</td>
<td>60.3</td>
</tr>
<tr>
<td>FAO - 56 modeled cumulative bare soil evaporation (mm)</td>
<td>24.7</td>
<td>18.3</td>
<td>51.5</td>
<td>87.9</td>
<td>84.4</td>
<td>47.1</td>
</tr>
<tr>
<td>Absolute value of the % difference between measured and FAO - 56 modeled cumulative E</td>
<td>2.1%</td>
<td>8.9%</td>
<td>2.4%</td>
<td>6.1%</td>
<td>3.9%</td>
<td>21.9%</td>
</tr>
<tr>
<td>Ratio of mean daily FAO - 56 modeled E/ETo to mean daily measured E/ETo</td>
<td>1.03</td>
<td>0.84</td>
<td>0.85</td>
<td>1.11</td>
<td>1.06</td>
<td>0.85</td>
</tr>
</tbody>
</table>

The E/ETo values estimated with the FAO - 56 procedure closely tracked the measured values (Figure 3-6), with a tendency to have either similar or a more pronounced response to large precipitation or irrigation events and to have a smoother and smaller response to smaller events. An example of corresponding FAO - 56 simulated and measured cumulative evaporation for experiments is displayed in Figure 3-7. The average ratio of the mean daily-modeled E/ETo to the mean daily measured E/ETo was 0.98 for the 5 lysimeter experiments. The average absolute value of the percent difference between the measured and the FAO - 56 modeled cumulative evaporation for these experiments was 4.7% (Table 3-3).
1.2.2 Soil Evaporation with Drip Irrigation

Discussions with irrigation dealers and farmers almost always bring out their opinion that evaporation is considerably less with drip irrigation than with other irrigation methods. Conversations with and a search of publications by academics and researchers, however, gave less credence to the notion of reduced soil evaporation on typical drip/micro systems.
1.2.2.1 Interviews and Observations

Kincaid (2000) noted that in USDA/ARS Idaho field comparisons between sprinkler and drip irrigation he was not able to measure daily differences in evaporation between the methods. However, the ET (scheduling) model he uses estimates that for a bare soil condition the difference in surface evaporation between surface drip (or furrow) with partial wetting and sprinkler with full wetting could be as much as 50 percent of the potential ET for the first day after an irrigation, or until the surface is visually dry. As the crop approaches full cover this difference is reduced to probably less than 5 percent. On an overall seasonal basis, Kincaid estimated that overall water use efficiency when using surface drip, vs. center pivot or linear move, is increased by 5 to 10 percent.

Hsiao of UC Davis (T. Hsiao, 2000) is conducting research to identify potential savings in soil evaporation (E) by using surface drip as opposed to furrow. He notes that drip can reduce evaporation under two conditions:

1. When the crop or tree canopy cover is less than 100%
2. When the soil is light textured with a low water holding capacity. When the texture is light (i.e., sandy), the required time between furrow irrigations is sometimes reduced to 5 days, resulting in more opportunity for soil evaporation to occur.

The second point can be explained by the logic that under complete crop cover or when there is a good heavy soil, soil evaporation from surface drip is similar to that under furrow irrigation. This is because, although the drip wets a smaller area, that area is wet for much of the growing season, whereas with furrow irrigation, more of the surface area is wetted, but it dries, reducing the amount of soil evaporation.

1.2.2.2 Literature on Soil Evaporation with Drip Irrigation

Burt et al. (1997) noted that crop ET (ETc) will be less for a well-watered crop with dry soil and plant surfaces (as can be the case with SDI) than if the crop were irrigated with a method that wets the soil and plant surfaces. Further, the method that wets the soil surface can also result in more weed development and loss of applied water through weed transpiration. Evett et al. (1995b) identified that for treatments with similar canopy development, there is no difference in seasonal ET of drip irrigation and furrow irrigation. Evett et al. (1995b) hypothesized that improved yields for subsurface systems are most likely due to more water being available to the plants irrigated with those systems since, relative to surface drip, less of the applied water is lost to evaporation.
Using field measurements, Evett et al. (2000) compared surface and subsurface drip irrigation treatments for a corn-growing season in Bushland, TX, using the coupled mechanistic water and energy balance model ENWATBAL. The treatments evaluated were surface and 0.15 and 0.30m depth SDI. Daily irrigation was scheduled to replace crop water use as measured with neutron probe. Modeled transpiration was nearly identical for the three irrigation methods (about 430mm over 114 days following emergence), but soil evaporation for the two SDI treatments were 51 and 81 mm less respectively than the surface treatment. The higher soil evaporation for the surface treatment was reported to have occurred during the partial cover period. From their work, Evett et al. (2001) estimated that water savings of up to 10% of seasonal precipitation and irrigation could be achieved using 0.3m deep SDI emitters. Blaine Hanson of the UC Davis Dept. of LAWR indicates similar data and thoughts with processing tomato research near Five Points, CA (Blaine Hanson, personal communication, Feb. 2001).

Ayars et al. (1999) reviewed 15 years of research from the USDA-ARS Water Management Research Laboratory, Fresno, CA. Cited is Phene et al. (1987), who reported that with SDI, E was minimal, while T increased. The high T with the SDI systems was postulated to improve evaporative cooling of the crop canopy, and to increase stomatal opening and photosynthesis. Evaporation from winter rains and from pre-irrigations by sprinkler or furrows, and evaporation from a wet seedbed for establishing a plant stand were not discussed.

The trend among California’s growers of lettuce, broccoli, cauliflower, peppers, and other similar crops is to move away from SDI and to surface retrievable drip systems because of the inherent difficulties in managing SDI in many situations. Management problems and surface wetting with SDI on orchards have been frequently observed (Burt and Styles, 1999).

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Dasberg (1995) found that sprinkler irrigations and micro irrigation that resulted in similar soil surface wetting resulted in similar amounts of the soil evaporation component of ET.

Burt and Styles (1999) and Burt (2000) note that some types of drip/micro system conditions will create at least as much, and probably more, soil evaporation than will occur under furrow irrigation. The vast majority of drip/micro systems are above ground, and the wetted areas may be quite large with some crops and emitter designs. Those wet soil surface regions are almost continuously wet, contributing to a high soil evaporation loss. This was also noted by Bresler (1975) and Meshkat (2000). For about 15 years, Westlands Water District in the central San Joaquin Valley of California has collected district data which indicates 10 – 15% higher ET, part of which is E, for drip on almonds, as opposed to other irrigation methods (Westlands Water District Water Management Plan, 1993).
Simulations using the FAO - 56 method for this evaporation study showed that the evaporation losses under drip/micro can be considerable, and depend upon the type of drip/micro system used, the soil type, and the percent soil surface wetted area. Some of the simulated results are shown in Figure 3-9.

![Figure 3-9](image.png)

Figure 3-9. Crop evapotranspiration and evaporation as the fraction of wetted area. Stressed and non-stressed almond trees irrigated with drip or microsprayers on the western side of the San Joaquin Valley of California. Other than crop stress and soil wetted fraction, the same crop parameters used in the overall study were used to do this comparison. Adjustments for bare spots and decreased vigor were not taken into account.

**Recommendations**

1. This report provides statewide estimates of annual Transpiration and Evaporation from precipitation and irrigation. Only part of the Evaporation may be conservable. An economic analysis of the conservation potential of various measures should be developed. For example, the total average annual evaporation from irrigation is estimated to be approximately 2.7”. An investment in SDI, which might cost $1,000/acre, might save half of this water. The estimated cost/AF conserved should be compared with other available conservation options.
2. The majority of annual evaporation (4.7 million AF/year, or 69% of the total evaporation) is from precipitation. This implies that research on rainfall precipitation conservation merits further funding. This type of research has typically been conducted in the Midwestern states where the majority of land was not irrigated. It is clear from the literature review that mulches, for example, can help to conserve winter moisture. More research on crop stubble and soil mulches is warranted.

3. It is apparent that within a field, certain practices will result in higher or lower evaporation within that field. It is also apparent that within that field, an increase in evaporation will result in a lower transpiration if there is a growing crop. The tradeoff is not equal – the increase in evaporation is typically greater than the reduction in transpiration. However, what is not known is how the tradeoff extends beyond the boundaries of a field. For example, an increase in evaporation in one field may increase the relative humidity of the air, and therefore reduce the ET in downwind fields. If this tradeoff is substantial, local field evaporation suppression efforts may only have a 40% or 60%, for example, net impact on the water balance in a region. Further research could approach this problem both with localized remote sensing and also theoretically based on the apparent local rise in relative humidity.

4. The issue may not be so much one of reducing evaporation and transpiration, as it is one of increasing crop yield per unit of ET. Therefore, research, demonstration projects, and information dissemination on related topics, such as optimizing fertigation practices, is of high priority.

5. State and Federal programs that either report ET or require the reporting of ET should be consistent on the following:
   a. The crop ET for water balances should be de-rated (by 10% as a rough starting approximation) to account for bare spots and lack of vigor throughout fields. This is in contrast to ET values to be used for irrigation scheduling. Both sets of values are provided on ITRC’s web page http://www.itrc.org/ETWeb/WBandlSHomePage.htm
   b. ET values for irrigation district water balances should be for a year, not just for a crop season.
6. The California DWR CIMIS program should initiate a new type of quality control program which performs a quality control check on the historical solar radiation (Rs) and relative humidity values for each weather station. Erroneous data should be replaced or flagged. Such a program does not presently exist, and therefore every individual research project must perform its own quality control check on historical data. In most likelihood, most users of the data are not aware that there may be data problems because the CIMIS program does insert flags on other types of problems. The present method of flagging obvious errors does not catch systematic instrumentation errors (of the type examined in this report) with solar radiation (the single most important value for ETo computations) or relative humidity.
Evapotranspiration and Relative Contribution by the Soil and the Plant
By Theodore Hsiao and Liukang Xu, UC Davis
Evapotranspiration and Relative Contribution by the Soil and the Plant

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Introduction

A field receives water as rain or irrigation. Some of this water may be lost in liquid form as runoff. Some, after infiltrating the soil, may continue to move deeper as liquid beyond the root zone and into the groundwater. Usually, the major loss of water is as vapor, by evaporating from the soil or being transpired by the plants growing on the soil. The liquid loss can be recovered either as ground water or stream flow by users downstream. The water lost as vapor is dissipated in the atmosphere, a huge sink, and cannot be recovered except as precipitation. For all intents and purposes, evapotranspiration from a field, consisting of both water transpired by plants and evaporated from the soil, represents an irreversible loss from that geographical location, and is referred to as consumptive water use.

Evapotranspiration or consumptive water use is usually beneficial, in that plants are grown and produced in exchange for the water used. Plants grow and acquire their biomass (dry weight) by assimilating carbon dioxide from the air via photosynthesis. To acquire carbon dioxide from the air, plants open their stomata, the microscopic control valves on the leaf surface, to let carbon dioxide diffuse into the leaves for photosynthesis. At the same time, water vapor escapes inevitably via the same open valves into the atmosphere. Hence, carbon dioxide assimilation and transpiration (T) are closely associated, and high production is usually linked to high crop water use, as long as that use is the result of transpiration (Tanner and Sinclair, 1983; Hsiao, 1993).

The consumptive use of water through soil evaporation (E), however, is not in exchange for carbon dioxide assimilation. Therefore it is usually considered to be non-beneficial use. This point of view is perhaps slightly too simplistic, and will be discussed in a later section. In any event, in managing the limited water resource of the state of California, it is important to know more accurately how much water crop fields evapotranspire, and how much of the evapotranspiration is due to soil E. It is also important to devise and develop means to minimize the E part of ET. This chapter presents pertinent information bearing on these points and is made up of two parts. The first part discusses ET in terms of the basic principles and important factors determining ET and the quantitative relationships. That is followed by a brief description of the methods used to separate out soil E from plant T, and a review of the literature quantifying the extent of soil E relative to ET. The second part reports on the results of experiments conducted to obtain additional information on the factors affecting ET and the proportion of E in ET, the extent ET is suppressed while water is applied by sprinklers, and the extent that crop T is likely to be increased by minimizing soil E.

Conceptual Background and Analysis of the Literature

Energy Supply for Evapotranspiration and Interactions Between E and T

For water to be evapotranspired, it must be converted from liquid form to vapor form. Water has an unusually high latent heat of vaporization—it takes approximately 2.45 kJ (580 calories) of energy to evaporate one gram of water. For a crop field, virtually all of this energy comes from the aerial
environment. By far the most important source of energy for ET is solar radiation absorbed by the field. This is known as net radiation transfer and consists of the incoming radiation minus the outgoing radiation. A minor source is the direct heating of the crop and soil by air going over the field, which occurs only when the air is warmer than the crop and the soil. This energy supply is termed sensible heat transfer. For many situations, the absorbed radiation is so dominating that daily or weekly ET from a fully wet field can be estimated from the net radiation over the field for the same period. The energy supplied by net radiation is divided by the latent heat of vaporization to obtain the amount of water evaporated. Such estimates often fall within 5 or 10 percent of the true ET. Deviation is caused by the warming or cooling of the field by the overhead air mass. ET (when converted to energy units) would be greater than net radiation if the air has a net warming effect on the field, and would be less if the air is mostly cooler than the field and has a net cooling effect.

If the rate of energy supplied as net radiation is suddenly reduced for an evaporating field by a passing cloud blocking the sun, ET would continue for a very short moment (seconds to minutes) at nearly the same rate, but with part of the energy supplied by the sun for evaporation now coming from the heat stored in the crop and soil. The loss of the stored heat to the evaporation process reduces the temperature of the crop and the soil. The cooler temperature then leads to a lower water vapor concentration in the crop and at the soil surface, which in turn slows down ET quickly after the cloud blocks the sun. If the energy supply is suddenly increased as the cloud moves away and the sun reappears, or by a warm wind, ET would remain momentarily at near the original rate, until the extra energy heats up the crop and soil. The higher temperature then raises the water vapor concentration in the leaves and at the soil surface, leading to an increase in ET.

Water vapor concentration in leaves and at the soil surface change with temperature because saturation water vapor concentration is strongly dependent on temperature, rising as temperature of the water increases (Clausius-Clapeyron equation). The air space network inside leaves is essentially saturated with water vapor. For any given soil water status (soil moisture tension), the air layer a few molecules thick adjacent to the soil is also nearly saturated with water vapor. Hence, changes in temperature of the leaves and the soil are associated with changes in water vapor concentration at the water losing surface.

Under favorable conditions with ample water supply when leaves are photosynthesizing at a high rate, stomata of most crop species are essentially fully open. In that case the foliage canopy acts essentially as a fully wet surface, transpiring at a rate similar to evaporation from a free body of water at the same temperature, covering the same land area as the canopy, and under the same aerial environment. This rate may be loosely referred to as the potential rate of transpiration, evaporation, or evapotranspiration. When plants are deficient in water or nutrients, and when temperature is too cold, stomata are less open and photosynthesis rate lower, the canopy would act as a surface that is less than fully wet, and transpiration would be below the potential rate. For the soil, evaporation is at the potential rate when the surface is fully wet and vapor concentration essentially the same as that of a body of water at the same temperature. When the soil surface begins to dry out and surface vapor concentration falls significantly below that of free water at the same temperature, soil E would fall below the potential rate.

Crop fields may be considered to be composed of three types of surfaces-canopy surface, exposed soil surface, and shaded and sheltered soil surface. Shaded soil surface receives very little radiation and is at a temperature considerably lower than that of exposed soil. This, coupled with the fact that it is generally subjected to less wind and under air of higher humidity because of transpiration of the canopy overhead,
limit its evaporation to a very low level. Consequently, one may assume that ET from a crop field is largely due to T from the canopy and E from the exposed soil surface. For situations of fully wet exposed soil surface and canopy with fully open stomata, the field acts as a fully wet surface as a whole, and evaporates at essentially the potential rate or slightly higher. For situations of partial canopy coverage of the soil combined with dry or not fully wet exposed soil, the field would evaporate at a rate lower than the potential and acts effectively as a surface that has dried to some degree.

**Reference ET and Crop Coefficient**

When the surface is fully wet, ET is at the potential rate determined by atmospheric conditions. The important weather variables are radiation, temperature, water vapor concentration (humidity) in the air, and wind velocity. An integrated measure of the capability of the atmosphere to supply the energy for ET and carry away the water vapor is reference evapotranspiration (ET$\_o$). ET$\_o$ is defined as “the rate of ET from an extended surface of a short green crop (usually a grass kept short by frequent mowing), completely shading the ground and not short of water or nutrients”. For practical purposes, ET$\_o$ is either the same or very similar to potential ET and may assumed to be the same. Instead of being measured on grasses, ET$\_o$ is now commonly calculated from weather data using certain formula, or derived from pan evaporation data. Sufficient research has been done previously to verify that the calculated results are in close agreement with the results measured on grass as a reference crop (Doorenbos and Pruitt, 1975). For different locations in California, the Department of Water Resources collects the weather data from a network of weather stations and makes the ET$\_o$ data available for downloading from its web site. Although defined with grass as a reference crop, ET$\_o$ takes into account the effects of weather and is indicative of the evaporative demand of the atmosphere. The influence exerted by the crop and the soil on ET, however, is not included in ET$\_o$. Crop and soil exert their control on ET mostly by altering the wetness of their surfaces. To a minor degree the roughness of the field, mostly determined by geometry of the vegetation, also exerts an effect. A rougher surface causes air moving over it to be more turbulent, enhancing the rate of ET slightly. In the common practical method of estimating ET, the impact of the crop and the soil is accounted for by a coefficient known as crop coefficient (Kc). Kc is defined as the ratio of crop ET to ET$\_o$, such that:

$$ET = K_c \cdot ET_o$$

Thus, Kc is essentially an integrated measure of the “effective wetness” and roughness of the surface of the field, while ET$\_o$ is an integrated measure of the evaporative demand of the atmosphere. Another way to consider Kc is to think of it as ET of the crop normalized for the evaporative demand of the atmosphere. The simple equation holds for different time intervals chosen, ranging from hourly ET to weekly and monthly means.

**Seasonal Pattern of ET of Annual Crops**

The life cycle of annual crops may be divided into three phases, each characterized by its own ET rate and somewhat different response to environmental or management factors. During the first phase, the foliage canopy, very sparse at the beginning, grows with time until it fully or nearly fully covers the soil. The second phase, usually lasting for several weeks or more, consists of the time period when the canopy is full and green with no obvious yellowing. This is the period when the crop produces dry matter at the highest rate due to high rates of photosynthesis per unit of land area. The third phase starts as the crop begins to mature and the older leaves senesce and turn yellow first, followed by younger and younger leaves, until the crop is fully mature or harvested.
An example of the pattern of ET of an annual crop over the first two phases plus the beginning of the third phase is given in Figure 1. ET₀, calculated from weather data, is depicted by the dashed line. Effects of day-to-day variations in weather on ET are discernible as indicated by the variations in ET₀. More importantly, features attributable to the development of crop canopy cover and changes in soil wetness stand out in Figure 1. For the first half of the graph, there is a gradual rise in base-line ET that can be visualized if one draws an imaginary smooth curve connecting the lowest ET rates for the first half of the graph. Added to this base line are several skewed ET peaks occurring after each irrigation. The peaks (referred to simply as irrigation spikes) are due to evaporation from the exposed soil surface after it is wetted by the irrigation water. As the soil surface begins to dry one or two days after an irrigation, soil E declines with time. The basal ET is due mostly to transpiration from the crop, plus some residual evaporation from the exposed soil at its driest point. In the first two or three weeks after planting, the plants have only very few leaves and the canopy covers only an insignificant portion of the ground. Therefore soil E accounts for virtually all of the ET. As the canopy of the crop develops, more and more of the ground is covered by the canopy, which continues to transpire regardless of the wetness of the soil surface, as long as the crop is obtaining sufficient water from the deeper part of the soil to keep its stomata open. Hence, base line ET rises with time in Figure 1, until the canopy covers the ground nearly fully.

With full ground cover, the canopy intercepts nearly all the radiation energy and accounts for most of the ET and soil E is not of much significance. ET is then insensitive to the wetting of the soil surface under the canopy, and hence is not affected perceptively by irrigation. In Fig. 1, the soil was mostly covered by the crop canopy about 55 days after planting. There were therefore no marked irrigation spikes in ET after that time, in spite of the irrigations. Near the end of the time interval shown in Fig. 1, older leaves of the canopy begin to turn yellow. This senescence apparently accounted for the decline in ET relative to ET₀ at that time. The dip in ET on days 54, 66, 74, and 75 after planting were the result of cloudy and cool weather as indicated by the low values of ET₀ on those days.
In terms of $K_c$, it is easily deduced from Fig. 1 that early in the season, $K_c$ is close to 1.0 only right after each irrigation because ET is close to $E_{TO}$ only then. Right after an irrigation the exposed soil surface is wet, and the canopy as usual, acts as a wet surface. Afterwards $K_c$ falls rapidly below 1.0 as ET falls rapidly below $E_{TO}$ because the effective wetness of the overall surface is decreasing due to drying of the exposed soil surface. After the canopy covers the ground nearly completely from day 55 onward, the value of $K_c$ is close to 1.0 as ET tracks $E_{TO}$ closely. The surface of the field stays fully wet during that time because the crop, fully covering the soil, is well supplied with water and its stomata are fully open. Near the end of the period depicted in Fig. 1, $K_c$ falls below 1.0 as ET falls below $E_{TO}$ due to the beginning of senescence of the canopy.

The impact of leaf senescence on canopy ET and $K_c$ is more clearly seen in another study on maize (Steduto and Hsiao, 1998). ET was measured on a dry treatment growing only on water stored in the soil and on a wet treatment (control) that was irrigated regularly. As shown in Fig. 2, due to water deficit the dry treatment senesced earlier; its green leaf area started to declined around 95 DAP, with the LAI falling from a value of 6 to about 1.5 over a period of 20 days. The LAI of the control also fell at about the same rate, but started considerably later, at around 110 DAP. Consequently, $K_c$ declined considerably earlier for the dry treatment than the wet treatment. There is some indication that a part of the difference in $K_c$ is the result of reduced stomatal opening in the dry treatment, but most of the effect is due to leaf senescence induced by water deficit (Steduto and Hsiao, 1998).
In contrast to the relatively smooth curves of $K_c$ vs. time one finds in most irrigation books (often in tabulated form), the value of $K_c$ deduced from Fig. 1 varies sharply from day to day for the first half of the figure. To a lesser extent that is also the case for the data in Fig. 2. That is because curves of $K_c$ in books are usually smoothed out to represent the mean value over a long period. It is clear that during the first phase of the life cycle of a crop, $K_c$ would vary with the number of irrigation spikes and area under the spikes and under the base-line ET. These in turn, will depend on the frequency of wetting of exposed soil surface and on the degree of canopy cover. Thus, $K_c$ would be dependent on rainfall events and on the schedule of irrigation, as well as on the starting canopy cover and the rate of canopy development.

Starting canopy cover in turn is partly dependent on density of the planting. Since all these items vary from location to location depending on conditions, $K_c$ for the first phase would vary also. Thus, values of $K_c$ for the first phase taken from the literature can only serve as a very rough approximation, and should be adjusted according to location conditions and practices. Similarly, because the starting time and rate of canopy senescence are usually affected by crop nutritional status, water deficit and temperature regimes, $K_c$ for the third phase also can only be taken as an approximation and should be adjusted for the time of onset and rate of senescence.
Evapotranspiration and Relative Contribution by the Soil and the Plant

The preceding discussion also makes clear that not only the total ET, but the proportion of soil E making up ET depends too on the frequency of wetting of soil surface and the degree of canopy cover, and hence, should vary with local conditions and practices. At the same time, the discussion points to some possible options to reduce the E portion of ET, a topic to be taken up later. First, it is necessary to know how much of ET is due to soil E and under what conditions.

Measuring or Estimating E and T Separately

A fair number of papers have been published reporting separate estimates of soil E and plant T. Before considering these data and judging their reliability, it is necessary to consider the difficulties involved in making these estimate and review the methods used.

It may appear to be simple to separate out the rate of plant transpiration (T) from soil evaporation (E). In fact it is difficult to do. One important reason is that the plants and the soil share the same energy source and the same or closely overlapping aerial environment; therefore T and E interact. For example, in the case of a partial canopy cover with a substantial portion of the soil surface exposed and wet, soil E would cool the surface soil and the adjacent air, and humidify the adjacent air. Hence, the plants would be cooler and transpiring in a more humid environment, and T would be less compared with the situation when the soil surface is dry. If exposed soil between plants is covered to eliminate E, plant T would increase to some extent because the energy that would have gone to support soil E is now partly available to enhance plant T.

Another cause of the difficulties encountered in separating out T from E is the fact that the water evaporated from the soil or transpired from the plants comes ultimately from the same reservoir in the soil, and the rate of water depletion from this reservoir determines how wet or dry the soil surface would be and its rate of E. If one isolates a portion of the soil in a container to measure E from that portion, there would be no root removal of water from that portion, nor drainage or capillary rise of water from the soil layer below. This will lead in time to a soil surface different in wetness and vapor concentration than that of the non-isolated soil.

Since soil E and T interact, either of them can be measured simply by eliminating the other. Measuring the rate of water loss after removing the plants would overestimate E, and measuring after sealing the soil surface to eliminate soil E would overestimate T. In both cases the measured rates would be higher than the rate taking place with the original spatial pattern of plants on the soil, because eliminating one liquid-to-vapor conversion process would make the air drier and more energy available for the other process. It is necessary to measure one in the presence of the other to obtain realistic values. There are only a few ways to do this directly, and more ways to do it indirectly.

For fields with crops growing soil E is normally measured with microlysimeters, made by filling small (e.g., 1-liter) containers with the soil and burying the containers between crop rows. The weight loss of the microlysimeters over time on an area basis provides a measure of soil E for the field. For the measurement to be reliable, the following conditions must hold: (a) The position of the microlysimeters relative to the plants must be representative of the field. This is normally achieved by placing several lysimeters at equal distance between two plant rows, and replicating the lysimeter arrays at several locations. (b) The surface of the soil in the microlysimeter must be similar to that outside in smoothness and consolidation. This can be achieved by fitting an virtually intact core of soil in the lysimeter, or by
packing disturbed soil inside the lysimeter and letting the soil consolidate over one or more wetting/drying cycles. (c) The soil surface within the lysimeter must be nearly identical in water status as that of the soil adjacent to the lysimeters. This is difficult to achieve if the lysimeter, once installed, is used over a long period, because the soil inside is hydraulically isolated from that outside and roots are not inside the lysimeter to remove the soil water as it occurs outside. This problem can be overcome by installing sets of lysimeters frequently and measuring the weight loss of each set only over a short interval of a day or two. Alternatively, a large number of lysimeters may be installed, watered in a way to obtain a narrow range of surface wetness similar to that of the soil outside, and then measuring the weight loss only of those with wetness of the soil surface matching that outside. Wetness of the surface can be matched by measuring surface temperature with an infrared thermometer and choosing only lysimeters with surface temperature nearly identical to that of the soil outside under similar canopy shading. Unfortunately, to our knowledge this promising method, although alluded to in a publication (Walker, 1984), has rarely been applied to making measurement of soil E. Another way to ensure the match is to measure vapor pressure of the soil surface inside the lysimeters with the instrument of Seymour and Hsiao (1984).

Soil E has also been estimated from measured changes in water content of shallow layers of surface soil over time. This procedure is fraught with problems because water content may be changed by root water removal and vertical water movement within the soil, in addition to surface evaporation. Ritchie and Burnett (1971) ameliorated a part of this problem by relating lysimeter measured bare soil E rate to surface (3 cm layer) soil water content and using the relationship to deduce soil E from measured surface soil water content. This does not, however, take care of the root water removal problem. Another way to estimate soil E is to apply the Bowen ratio/energy balance (BREB) approach to measure the upward latent heat flux in the air very close to the surface of the soil between widely spaced crop rows (Ashktorab et al., 1994). Though novel, the estimates are likely confounded since gradients of temperature and humidity in the horizontal direction are probably marked and the normal fetch requirement for using the BREB technique is not met.

As for transpiration, T of single plants is now estimated by measuring the rate of upward flow of water in the plant stem. The assumption is that this rate is equal to the rate of T, a good assumption when measuring over a 24-hour period. When the measurement covers shorter periods (e.g., hourly), the results can be quite inaccurate because there is usually a substantial lag in the upward water flow behind transpiration in the morning, and in the transpiration behind the upward flow in the afternoon. The technique relies on the fact that applied heat would be carried by flowing water. By applying heat to the basal part of the stem, water flow is inferred from heat flow based on temperature measurements. The simpler method is to determine the rate of heat pulse traveling up the stem by applying pulses of heat at the base and determining the time it takes for the change in temperature to reach a measured distance up the stem from the point of heat application. The measurement yields the velocity of water flow. To obtain the flow rate or quantity of water flow per unit of time, the measurements have to be calibrated against measured rate of transpiration. The method is inaccurate because due to differences in xylem geometry and blockage from plants to plants, the calibration obtained from one plant may not be applicable to another. A better way is based on balancing the heat input to the stem against the heat outflow, yielding directly the rate of flow. The base of the stem is wrapped in an electrical strip heater and the heat input measured in watts. Thermal couples are placed to measure the temperature gradients up and down stream from the heater, and radially across the insulation wrapped outside of the heater. These data, together with thermal conductivity of plant stem and of the heater insulation, are used to calculate with heat transport
equations the heat lost by thermal conduction. The difference between the heat input and loss by thermal conduction indicates the amount of heat transported away from the heater by water flow in the stem. Water flow is then computed from the heat capacity of water and the temperature data.

For the stem flow to be indicative of T of the field, a relatively large number of representative plants must be measured simultaneously. This can be expensive if commercial stem flow gauges are used, especially if the measurement is over many days when stems of the plants are enlarging, necessitating changing over from gauges of one size to gauges of progressively larger sizes.

Soil E and canopy T can also be estimated indirectly. An early method is to sample plants for dry weight and measure ET periodically as the plants grow, and then plot the dry matter produced versus the cumulative ET. Usually the relationship is linear and the line intercepts the ET-axis at a value considerably higher than zero. This intercept value is taken as the total amount of soil E. The underlying assumption is that the amount of dry matter produced at different growth stages of the plant is proportional to the cumulative amount of water transpired up to that time, a fairly reasonable assumption (Fischer and Turner, 1978). Plant T is then the difference between soil E and total ET.

The most obvious indirect way to estimate soil E and canopy T separately is by model simulation. The models are some times very simple but inaccurate. For example, by assuming that soil E declines linearly with time after a soil wetting. More complicated models estimate advective transfer of energy and water vapor between the soil and the canopy environ (e.g., Shuttleworth and Wallace, 1985), but require either simplification of fundamentally complex situations or parameterization for different conditions.

Still another way to estimate canopy T indirectly is to calculate it from measured leaf conductance and leaf area. This involves much uncertainty because the scaling up process, from the leaf level to canopy level, is still experimental and not yet well worked out.

**Magnitude of Soil E Relative to ET as Reported in the Literature**

In the published studies, soil E was reported to range from a few percent to as much as over 80 percent of the measured or estimated ET. Because of the difficulties encountered in measuring or estimating E and T separately, there is considerable uncertainty in some of the reported results. Nonetheless, some firm data from several studies, together with the relatively consistent conclusions drawn in many other studies of less definitive nature, permit a fairly quantitative assessment. These studies are examined in some detail here, starting with the cases where soil E constituted the major portion of ET and ending with situations where soil E is minimal.

As expected from the previous discussion on factors affecting soil E and plant T, high ratios of E to ET are observed mostly when canopy cover or LAI (leaf area index, leaf area per unit land area) of crop is low and the soil surface is wet or at least not very dry much of the time. Examples are the results obtained by several groups when soil E was measured with microllysimeters under sparse canopies just a day or two after soil surface was wetted. Lascano et al. (1987) found soil E for a cotton field under a LAI of 1.0 to be slightly higher than 5 mm per day on days when \( ET_0 \) should be in the range of 7 mm per day as judged by the level of solar radiation. Villalobos and Fereres (1990) measured soil E to be 60-80 percent of \( ET_0 \) for sunflower, maize and cotton with LAI of 0.6 to 1.2. For longer terms but with parts of soil surface drying intermittently, Sadras et al. (1991) found soil E, measured by microllysimeters installed freshly each week, to be 50 percent of ET for two cultivars of sunflowers over a period of 64 days starting...
33 days after crop emergence. The plants were spaced widely apart with LAI reaching a maximum of only 1.4 in one cultivar, and 0.9 in the other. Hence, a high proportion of the soil remained exposed for the whole season. The crops were drip-irrigated with 23 to 42 mm of water per week, and there were two rains, of 12 and 8 mm. Presumably a substantial fraction of the soil surface remained wet most of the time. For treatments with irrigation omitted and the soil surface allowed to dry out during either the first half or the second half of the test period, soil E for the 64 days was reduced to 30-35 percent of ET.

Similarly high proportion of soil E was also reported by Lascano and Baumhardt (1996). They used the ENWATBAL model to assess dryland cotton during a period when the LAI started at 0.5-0.9 and reached 1.9 later. There was one furrow irrigation of 100 mm at the beginning of the assessment period and some nine rainfall events totaling 225mm. The simulation daily soil E over a 7-day period after the irrigation was in good agreement with the results measured by microlysimeters (Lascano et al., 1994). For the whole assessment period of 90 days, the simulated soil E was 50 percent of ET.

As the crop canopy covers a greater and greater portion of the ground, soil E becomes less and less. With the exception of crops planted in very widely spaced (e.g., 60 inches or 1.5 m) rows, canopy cover is usually nearly complete (e.g., 95 percent percent) when LAI is 4.5 or higher. In such situations, soil E constitutes a minor portion of ET, even when the soil surface is fully wet. Adams et al. (1976) and Arkin et al. (1974) used arrays of evaporation plates covered with a thin layer of soil to measure soil E after sprinkler irrigations. E of fully wet soil surface as a fraction of ET declined as LAI increased and shading of the soil increased. When the soil was nearly fully shaded, soil E was still 18 percent of the potential value. Jara et al. (1998) combined extensive measurements of T with stem flow gauges, soil E with microlysimeters, and total ET with BREB technique to assess the extent of soil E for maize irrigated by furrow six times during a 64-day period when LAI increased from 3 to 5.2 and then decreased to 4.5. They found daytime soil E, measured by microlysimeters and averaged for 28 days of observation that included up to 6 days after each irrigation, constituted 13.6 percent of daytime ET. But soil E calculated as the difference between ET and T measured by stem flow, averaged over 40 days and including days later than 6 days after an irrigation when the soil surface was drier, constituted only 9 percent of the daytime ET. Although this difference may not all be due to differing soil surface wetness, the data nonetheless show that E was a fairly small fraction of ET when LAI was high. This conclusion is also supported by the results of Bethenod et al. (2000), who studied maize over a 17-day period one year, and a 46-day period the next year. During the study periods, canopy cover of the soil was complete with a LAI of around 4.0. Rainfall, mostly light, was frequent, with the longest dry period being 16 days, and the next longest, 6 days. Overall, the data showed that if soil E was taken as the difference between ET measured by the BREB technique and T measured by stem flow gauges, soil E was approximately 10 percent of the ET.

The higher proportion of soil E under high LAI or canopy cover measured by Arkin et al. (1974) and Adams et al. (1976) in comparison with that measured with microlysimeters and stem flow gauges (Jara et al., 1998; Bethenod et al., 2000) may partly be attributed to the fact that the surface of the evaporation plate used in the former case remained fully wet all the time, whereas in the latter case the soil surface dried out at least to some extent between wettings by rain or irrigation. There might also have been some systematic differences caused by the use of different techniques. Nonetheless, it appears safe to conclude that when canopy cover of the ground is essentially complete, soil E may constitute 10 or 15 percent of ET under normal weather or irrigation conditions with periodic drying of the soil surface, and somewhat more if the soil surface remains fully wet all the time.
Evapotranspiration and Relative Contribution by the Soil and the Plant

Over the full range of canopy cover or LAI, it is desirable to have a function (curve) relating soil E to the LAI or percent of canopy cover. In the literature a number of empirical curves have been constructed from experimental data. Four of them are presented here in Fig. 3. It is seen that generally the curves deviate from each other. The only consistency is that they all show soil E relative to ET or ET₀ to decline exponentially with increase in canopy cover or LAI. In considering these curves, it is important to note a number of uncertainties. For one, the soil surface condition may not be as well defined as desired. For example, in the case of Curve (d) obtained by Ritchie and Burnett (1971), soil surface is assumed to be fully wet but in fact could be partially dry because stage 2 evaporation was taken to start after 10 mm of water has evaporated since wetting of the soil whereas their Figure 3 showed stage 2 already started after only 5 mm of water has evaporated. The second uncertainty is that in the case of the relationship with LAI, it will depend on the geometry of plant distribution. The more uniformly the plants are distributed on the land, the more effectively they would shade the soil and reduce soil E. As already mentioned, wide spacing between rows with plants densely spaced along the row will require a higher LAI to shade the same proportion of soil as compared to more narrow distance between rows with plants less densely spaced along the row. Another caveat is that the values are estimates in the case of Curve (d). It was assumed that soil E was equivalent in energy terms to the net radiation measured below canopy when soil surface is wet (Ritchie and Burnett, 1971).

Experimental Studies

As a part of the effort to assess the extent of E relative to ET, to quantify better crop ET and consumptive water use, and to better define the conditions that affect ET, several field studies were carried out in 1999 and 2000 supported by funds from DWR. These studies and the results are described by topics below.

ET of Crops at Two Plant Densities-Indirect Assessment of Soil E

Growing plants at a higher density results in a faster foliage canopy development and more coverage of the soil in the early part of the season. As already discussed, this would reduce the proportion of ET lost by soil evaporation and increase the proportion lost by plant transpiration. Detailed data on ET as affected by plant density are rare. This part of the project is to develop more such data and to assess how much of the soil E may be saved by planting at higher densities.

Methods

The two large (6.1 m diameter) lysimeters at the experimental field of the University of California, Davis were planted on June 4, 1999 with cotton, at a density of 25 plants per m² for the weighing lysimeter (WL), and 8 plants per m² for the floating lysimeter (FL). The two lysimeters have essentially the same sensitivity and resolution for measuring ET.

A large area surrounding the lysimeters was also planted with cotton of similar density at the same time, to provide adequate fetch or upwind guard area. The lysimeters were routinely irrigated by filling the furrows between beds with water at the time when the surrounding field was furrow-irrigated. However, early in the season the work on the extent ET is suppressed during sprinkler irrigation (see a later section) was also conducted on the lysimeters, entailing the application of water by sprinklers on a number of days. Canopy coverage of the soil was measured periodically by the light interception method with a 1-m long light sensor. ET was monitored over the season by measuring changes in the lysimeter output voltage, calibrated as changes in weight and converted to changes in water content per unit land area. A data logger scanned the output every 1 second, and calculated and stored the mean for each 5 min
interval. The data were downloaded to a computer, adjusted or corrected for the occasional resetting of the sensing mechanism, perturbations caused by persons walking on the lysimeters to take measurements, and irrigations. Daily ET rate was obtained from the adjusted data by summing the 5-min means.

Results and Discussion
The patterns of daily ET for the two densities over the season are presented in Fig. 4, with each sprinkler irrigation (associated with the work of a later section) denoted by an open triangle, and furrow irrigation, by a closed inverted triangle. Also presented in the same figure are the data on canopy cover. Early in the season when the canopy cover was small, each irrigation caused a large increase in ET (irrigation spike) because of wetting of the exposed soil surface. As the soil surface dried over time, soil E decreased fairly rapidly and hence ET also. Later in the season when the canopy covered more of the soil surface, irrigation did not cause sharp increases in ET, and the variation in ET from day to day was caused instead by variations in weather conditions affecting the evaporative demand, as indicated by the ETs curve (Fig.4c).

Canopy cover developed much faster with the high plant density (WL), reaching 80 percent around 60 DAP (Fig. 4a), whereas with the low plant density (FL) 80 percent cover was not reached until the end of the season (Fig. 4b). Early in the season the base line ET (minimal values between the high ET peaks caused by irrigation) may be taken as a very rough approximation of canopy T. Comparing Fig. 4a and 4b this way, one may surmise that E accounted for a higher proportion of ET at the low plant density (FL). The total ET over the 140-day period was 662 mm for the high plant density and 606 mm for the low plant density, a difference of only 9.2 percent. Dry matter production of plants have been shown to be nearly proportional to the cumulative radiation captured by the plant canopy (Ritchie, 1983). Hence, the relative areas under the canopy cover curves are indicative of the relative total amount of dry matter produced at the two plant densities. On that basis, it may be concluded that for an additional consumptive water use of only 9.2 percent, there was a much larger percentage increase in dry matter produced at the high plant density. That is because a larger proportion of the water used went to soil E in the low density planting compared to the high density planting.

For a more clear cut comparison between two plant densities, we refer to some early data collected with the same lysimeters under another research project (Hsiao and Henderson, 1985) funded by DWR. Beans were planted at two densities, 19 plants m⁻² in rows spaced normally (normal density), 76 cm apart, and 38 plants m⁻² in narrow rows 38 cm apart (high density). Irrigation was by sprinkler. The daily ET rates of the two densities are presented in Fig. 5, along with the canopy cover data. As can be seen in Fig. 5, ET rate was higher for the high density planting for the first two thirds of the graph, with most obvious difference in the base line ET. The higher base line ET was associated with the faster canopy development of the high density field. This supports the interpretation that when canopy cover is incomplete, base line ET is mostly due to canopy T when irrigation intervals are long enough to permit the drying of exposed soil surface. After most of the soil is covered by the canopy (day 55 onward), there was very little difference in ET between the two densities. The model of Hsiao and Henderson (1985) that calculated E and T separately was used to simulate the ET of the two densities. As shown in Table 1, the simulated soil E for the low density planting was 101 mm or 28 percent of the total ET for the low density, and 44 mm or 11 percent of the total ET for the high density. The simulated results appear to be realistic in that the simulated total ET for the low and high density were, respectively, 362 mm and 406 mm, values surprisingly close to the measured total ET of 358 mm for the normal and 395 mm for the high density.
Evapotranspiration and Relative Contribution by the Soil and the Plant

\[ \frac{E}{ET_0} = e^{(-0.017 \text{ GC})} \]

\[ \frac{E}{ET_0} = 416.4 e^{(-0.055 \text{ GC})} \]

\[ \frac{E}{ET_0} = e^{(-0.41 \text{ LAI})} \]

\[ \frac{E}{ET_0} = 1.21 - 0.7 \text{ LAI}^{0.5} \]

Figure 3. Empirical relationship between ratio of soil E to ET or ET\(o\) and crop canopy cover or LAI. Equations described by the curves are given in the figure. Curve (a) represents the equation of Adams et al. (1975) fitting their experimental data on sorghum, and the equation of Villalobos and Fereres fitting their data on corn, cotton and sunflower; Curve (b) represents an equation fitting the data of Ashktorab et al. (1994) on tomato; Curve (c) represents the equation of Villalobos and Fereres (1991) fitting their data on corn, cotton and sunflower; and Curve (d) represents an equation derived from the equation of Ritchie and Burnett (1971) for T/ET\(o\) vs. LAI fitting their data on cotton and sorghum.
Figure 4. Lysimeter measured ET of cotton planted at two densities, 8 plants m$^{-2}$ for the floating lysimeter (b), and 25 plants m$^{-2}$ for the weighing lysimeter (a). Percentage of canopy cover and ET$_{o}$ provided by the Davis CIMIS weather station nearby are also shown.
A reasonable conclusion would be that the percentage of ET going to soil E can be reduced substantially by narrower row spacing and higher planting density. On the other hand, this would result in a higher total ET because of the increase in canopy T. Higher canopy T, however, is associated with higher productivity, as already discussed.

**Comparison of ET Between Drip and Furrow Irrigated Fields**

Drip irrigation is often said to save water because only a portion of the soil surface is wetted at each irrigation. While this is likely true for young orchards with trees spaced far apart and most of the soil not shaded, the validity as a general case may be questioned. This study was conducted to obtain more data bearing on this question.

**Methods**

Cotton was planted on June 13, 2000 in the two Davis lysimeters and surrounding field at the same density. One lysimeter (FL) and adjacent area was irrigated by a surface drip system, and the other and adjacent area, by furrow irrigation. Weight loss by the lysimeters were monitored to calculate ET rate; and canopy cover on each lysimeter was measured periodically. During the early phase of growth, plants on the FL were less green and grew slower than plants on the WL and surrounding area. Tests indicated that the soil of the FL was slightly more saline and basic than the soil of the WL. Extra water was applied at irrigation time the FL to leach the soil and reduce the salinity. The FL plants soon recovered and started to grow normally. To account for the difference in canopy cover, an adjustment in the ET data was made. The excessive canopy cover of the WL (in percentage), calculated by subtracting the canopy cover on the FL from that on the WL, was divided by 100 and multiplied by an assumed crop coefficient of 1.1, and the result was added to the measured ET of the FL.

**Results and Discussion**

The rate of daily ET under drip and furrow irrigation as measured by the lysimeters are given in Fig. 6, along with the data on canopy cover. Because of the salinity problem with the FL, there was a substantial difference in canopy cover between the two irrigation methods in the first part of the season and it was desirable to adjust the ET data for the difference in canopy sizes as described under methods. The adjusted ET data are presented in Fig. 6c. It is seen in Fig. 6a and 6c that the most obvious difference in ET between the drip and furrow irrigated lysimeter in the first 50 days is the lack of irrigation spikes in the former and the prominence of irrigation spikes in the latter. In addition, not as obvious but still clear is the higher ET of the drip irrigated lysimeter starting several days after one furrow irrigation and lasting until the next furrow irrigation. These differences are the result of fundamental differences in the two water application methods. With furrow irrigation, the spikes and the rapid decline are caused by the sudden wetting of the whole soil surface, followed by surface drying and stage 2 exponentially declining evaporation rate from exposed soil surface. With drip irrigation, only a portion of the exposed soil surface is wetted at each irrigation but this portion stays fully or fairly wet most of the time due to the short time intervals between irrigations. Hence, during the time when the furrow irrigated soil surface had dried out enough to limit soil E markedly, the ET of furrow irrigated lysimeter is less than the ET of the drip irrigated one because the latter has a part of its soil surface still wet.
Figure 5. Evapotranspiration and canopy cover of bean planted at two densities, 19 plants m$^{-2}$ (normal, with 76 cm row spacing) and 38 plant m$^{-2}$ (high, with 38 cm row spacing). Inverted solid triangles indicate sprinkler irrigations. Measured canopy cover is given as circles; lines are fitted using the canopy growth model of Hsiao and Henderson (1985). Same experiment as that shown in Fig. 1.
Table 1. Cumulative soil E and canopy T and ET as predicted by the model of Hsiao and Henderson (1985) in comparison with cumulative ET as measured by lysimeters, for fields of beans planted at two different densities. Data are for a period of 79 days starting 1 day after planting.

<table>
<thead>
<tr>
<th>Plant Density</th>
<th>Soil E (mm)</th>
<th>(%) of ET</th>
<th>Crop T (mm)</th>
<th>(%) of ET</th>
<th>ET (mm)</th>
<th>(%) of ET</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 plants m⁻²</td>
<td>101</td>
<td>28</td>
<td>261</td>
<td>72</td>
<td>362</td>
<td>100</td>
</tr>
<tr>
<td>38 plants m⁻²</td>
<td>44</td>
<td>11</td>
<td>362</td>
<td>89</td>
<td>406</td>
<td>100</td>
</tr>
<tr>
<td>Measurement</td>
<td>358</td>
<td>----</td>
<td>395</td>
<td>----</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Over the period of 90 some days, the measured total ET was 436 mm for the furrow irrigated (WL), and 387 mm for the drip irrigated (FL). After adjusting for the difference in canopy cover (see Methods), the total ET for the drip irrigated was 426 mm. Assuming the adjustment is reasonable, the similarity in total ET between the furrow and drip irrigated cotton indicates that drip irrigation does not necessarily save water in some situations. This conclusion is consistent with those drawn in several other careful studies (e.g., Tarantino et al., 1982). In the current study, the frequent wetting of a part of the soil by drip irrigation kept the ET high during the periods when ET of furrow irrigated treatment was low due to soil surface drying over the long intervals between irrigations.

**Extent crop ET is Suppressed During Sprinkler Irrigation.**

Sprinkler irrigation is sometimes said to be wasteful because after being emitted by the sprinklers, the water drops evaporate partly in the air before reaching the soil and the crop. In terms of the energy balance principle, however, in-air evaporation from the water drops should reduce the energy supply to the field and cool and humidify the air, leading to reduced rate of ET from the soil and the crop. This study was conducted to quantify the extent surface ET is suppressed during sprinkler irrigation.

**Methods**

The two lysimeters were planted with cotton in 1999 and 2000. To determine the extent ET is suppressed, the normal rate of ET (control) without sprinkling must be known, and one lysimeter (FL) was used for this purpose. The other lysimeter (WL) was used to determine the ET rate under sprinkler application. To measure ET from the soil/crop surface during sprinkler application, the amount of water applied and reaching the surface must be accurately measured and deducted from the change in weight of the lysimeter. Sixty small platforms each with three supporting legs were distributed on the lysimeter. A catch can was placed on each platform and carefully leveled with a spirit level. A layer of oil about 1 cm thick was added to the can to prevent evaporation of water caught in the can. The can with its content was weighed before and after the sprinkler application, to 0.1 g accuracy, to determined the depth of water applied. Tests conducted with cans containing water dyed brightly red and placed on white paper sheets showed that there was no detectable splatter from the can during sprinkling. After adding water to cans containing oil, weight of the cans did not change significantly after sitting in the field for a number of hours, indicating no evaporative loss. For each test run, the FL was irrigated by sprinkler to ensure that its top soil layer is fully wet. The irrigation was stopped just before applying water to the WL (equipped with
catch cans) by sprinklers. The reported rate of ET measured by the WL has been corrected for the surface area occupied by the non-evaporating catch cans.

**Results and Discussion**

Figure 7 shows an example of the change in weight of the two lysimeters with time during the test. The continuous gain in weight for FL between 11:20 and 14:00 was the result of water application by sprinklers. After the application was stopped, the continuous loss in weight of FL with time was due to ET. At about 14:05 the sprinklers were turned on to apply water to the WL, which gained weight continuously until the application stopped at 16:30. The water applied as measured by the catch cans minus the water gained by the lysimeter between 14:05 and 16:30 was taken as the cumulative ET from the WL during the sprinkler application.
Figure 6. Trend of daily ET, \( E_{T_o} \), canopy cover, and daily crop coefficient (\( K_c \)) for cotton under drip irrigation (floating lysimeter-FL) or furrow irrigation (weighing lysimeter-WL). Comparison of crop ET for the two irrigation methods after adjusting for the effect of the lower canopy of the drip irrigated (see Methods) is given in (c). Downward triangles indicate the time of furrow irrigation. Planting was on June 13, 2000.
Figure 7. Example of weight change of the weighing and floating lysimeters during the determination of surface ET while under sprinkler irrigation. Weight was measured from an arbitrary reference point and was not the total weight of the lysimeter. The rapid changes in weight between 13:00 and 14:00 were due to weight of the researchers setting up the catch cans, and around 16:45, weight of the researcher taking away the cans for weighing.

Of the total eight tests conducted in 1999, three of them gave unacceptable values of ET under sprinkler irrigation, either much higher than the control ET and ET\textsubscript{o}, or negative values. The results of the remaining five tests and the four tests conducted in 2000 the mean values are presented in Table 2. As can be seen, the variation from test to test was large and less definitive than we had hoped for. It can be seen from the slopes of the lines in Fig. 7 and in Table 2 that ET during sprinkler application is very small relative to the application rate, and hence, relatively small errors in the amount of applied water measured by catch cans can lead to a large error in the calculated ET under sprinkling.

The reduction in ET under sprinkling as a percentage of the control ET was calculated for each test and given in Table 2. For the 1999 tests, the mean percentage reduction was 48 percent, and for 2000, the mean was 46 percent. The overall mean reduction was 47 percent for the nine tests in two years. A
reasonable conclusion would be that during water application by impulse sprinklers, surface ET is substantially suppressed, although in-air evaporation of the spraying water drops probably makes up for the difference and more.

**Table 2. ET rate of a cotton field under sprinkler irrigation relative to ET rate not under irrigation (control ET). Reduction of ET rate under sprinkling is given as a percentage of the control ET rate.**

Control lysimeter was irrigated by sprinklers first, then the sprinklers were turned off at the start of the ET measurement. ET rate was calculated as the difference between the water application rate measured by catch cans and the water gain rate measured by lysimeter.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time (Pacific standard)</th>
<th>$E_T$ (mm h$^{-1}$)</th>
<th>Lysimeter water gain rate (mm h$^{-1}$)</th>
<th>Water appl. rate (mm h$^{-1}$)</th>
<th>Control ET (mm h$^{-1}$)</th>
<th>ET under sprinkler (mm h$^{-1}$)</th>
<th>ET reduction under sprinkler (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1999</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/18</td>
<td>14:00-16:30</td>
<td>0.65</td>
<td>4.79</td>
<td>4.96</td>
<td>0.80</td>
<td>0.17</td>
<td>79</td>
</tr>
<tr>
<td>6/21</td>
<td>11:00-14:00</td>
<td>0.72</td>
<td>4.74</td>
<td>5.40</td>
<td>0.85</td>
<td>0.65</td>
<td>24</td>
</tr>
<tr>
<td>7/1</td>
<td>12:00-14:30</td>
<td>0.82</td>
<td>4.92</td>
<td>5.48</td>
<td>0.93</td>
<td>0.56</td>
<td>40</td>
</tr>
<tr>
<td>7/2</td>
<td>11:00-13:00</td>
<td>0.80</td>
<td>5.01</td>
<td>5.60</td>
<td>0.89</td>
<td>0.59</td>
<td>34</td>
</tr>
<tr>
<td>7/20</td>
<td>12:40-15:10</td>
<td>0.70</td>
<td>5.72</td>
<td>6.00</td>
<td>0.76</td>
<td>0.28</td>
<td>63</td>
</tr>
<tr>
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**Extent Transpiration May Increase When Soil Evaporation is Minimized**

One idea for saving water is to minimize or eliminate soil E while not restricting crop T. During the early part of the life cycle of crops, only a part of the soil is covered by the foliage canopy and soil E is high if the soil surface is wet. If soil E is reduced, less energy is consumed by soil evaporation and air above and near the soil would be less humid and hotter. This in turn causes the canopy to be hotter and surrounding air to be less humid. T would increase as the result of a large humidity gradient ($\Delta$W) from the leaf to the air. Very little work has been done to quantify this effect by experimental measurements. This study was conducted to develop some of the needed information. The objective is to measure the increase in canopy temperature and the reduction in air humidity and use the data to calculate how much T would be raised by the reduction in soil E.
Methods

In a large field of cotton two adjacent plots, 15x15 m each, were demarcated. The plots were irrigated once or twice to establish the plant stand. On day 35 after planting in 1999, and day 44 after planting in 2000, irrigation began to be applied to the WET treatment every 14 to 20 days, while DRY treatment received none. Temperature of 18 mature leaves on top of the canopy in each plot was measured continuously with fine-wire (40 gauge) thermocouples attached on the lower side of the leaf. The thermocouples were checked every morning, and if they fell off the leaf, the readings back to the previous morning were excluded in the calculation of leaf temperature averaged over all the measured leaves. Vapor pressure inside the leaf was calculated from leaf temperature by assuming vapor saturation. This assumption has been shown to be valid by experiments and is used regularly in all published gas exchange studies. Water vapor pressure and temperature of the air 0.1 m above the canopy of each plot were measured with a precision psychrometer (Held et al., 1990), positioned at the center of each plot to avoid edge effects. Voltage outputs from the thermocouples and psychrometers were scanned every 1 second and averaged every 5 min by a data logger, and the means values stored.

The driving force for transpiration, the difference in vapor pressure between inside of the leaf and the bulk air surrounding the canopy (ΔW), was calculated from the calculated vapor pressure inside the leaf and the measured vapor pressure in the bulk air. To assess the impact of reduced soil E on canopy T, we assumed that the stomatal conductance are basically the same for the plants in the WET and DRY plot and the only effects on canopy T are those due to changes in temperature and humidity (vapor pressure), which alter ΔW. Since the rate of transpiration is proportional to ΔW for a given conductance, the increase in canopy T of the DRY plot due to the dry soil surface should be proportional to the increase in ΔW. That is, the percentage increase in T is the same as the percentage increase in ΔW. Using this approach, the increase in canopy T was calculated and added to the estimate T of the WET plot to obtain T of the DRY plot. Canopy T of the WET plot was estimated using our ET model (Hsiao and Henderson, 1985).

Vapor pressure at and temperature of the soil surface at random locations in the plots were measured periodically with a special instrument (Seymour and Hsiao, 1984). Air humidity at about 1 m height was also measured at the same time with the same instrument.

Results and Discussion

In both years soil surface vapor pressure increased markedly after each irrigation, then declined with time and became nearly the same as air vapor pressure after 10 days to 2 weeks. The data obtained in 2000 are given in Fig. 8. Very similar but less complete data (not shown) were obtained in 1999. Since vapor pressure of the soil surface and of the air became very similar at that time, soil E should be rather insignificant 10 days to 2 weeks after an irrigation.

The driving force for transpiration (ΔW) was calculated. Samples of the results in 1999 are given in Fig. 9 for two dates before an irrigation, the day of irrigation and the three days after the irrigation. It is seen in Fig. 9 that before the irrigation, ΔW was similar for much of the time each day between the WET and DRY plots, with ΔW for the DRY plots often slightly lower than that for the WET early in the afternoon. After the soil surface was wetted by the irrigation at 11:00 on July 23, ΔW became markedly smaller for the WET plot from in the morning. Six days after the irrigation, the difference in ΔW between the two treatments became much less.
Figure 8. Absolute humidity (vapor pressure) of the exposed soil surface and of the air for the Wet treatment as affected by furrow irrigation (inverted solid triangles), and for the Dry treatment not receiving irrigation. Canopy cover of each treatment are also shown. On 85 DAP, the plant was thinned to about 2.5 plants m\(^{-2}\) to reduce the canopy cover in order to have a higher proportion of exposed soil surface.

The 2000 data of \(\Delta W\) are presented as midday mean over a test period of over 70 days in Fig. 10. In the lower part of the figure the ratio of \(\Delta W\) of the Dry treatment to \(\Delta W\) of the wet treatment is shown. It is seen that this ratio increased substantially after each furrow irrigation, then declined over a period of several days to one week to a base value of 1.0.

Throughout the experiments in 1999 and 2000, there was no significant water stress in the plants of the DRY plot, as indicated by the absence of stress symptoms and a canopy size nearly the same as the WET
plot. That is due to the high water holding capacity of the deep Yolo loam soil at the experiment site, and fast development of the root system of many crops including cotton on this soil.

Using the estimated \( \Delta W \), the increase in canopy transpiration (T) caused by dry soil surface was calculated for the midday period over two irrigation cycles in 1999, and the results are presented in Fig. 11. Both treatments were irrigated the same way on 35 DAP and canopy T was similar for the WET and the DRY plots and the canopy cover was also similar. As expected, irrigation of the WET plot on 49 DAP caused a large difference in canopy T between the WET and DRY plots. This difference lessened gradually over time and became insignificant after about a week. The canopy grew from approximately 30 percent coverage of the soil at 49 DAP to 60 percent coverage of the soil on 63 DAP. The next irrigation of the WET plot, applied on 63 DAP, had no significant effect on canopy T. Most likely that was due to the fact that by then the canopy covered more than 60 percent of the soil, and heating of the small portion of the dry soil surface was insufficient to have a measurable effect on canopy temperature. Therefore the estimated canopy T was essentially not affected. Overall, compared to the intermittently wetted soil surface, dry soil surface was estimated to increase canopy transpiration by 17 percent over the 15 days of testing period (49 to 63 DAP).
Figure 9. Vapor pressure difference ($\Delta W$) between the interior of leaves and the air for cotton in the WET and DRY treatments on six dates in 1999. Irrigation of the WET plot was on 7/23 starting about 11:00.
It should be pointed out that the above estimates of the potential increase in canopy T are likely to be on the high side. The estimate was based on midday data, when intrarow advective effect is expected to be the greatest. Basing the estimate on the cumulative daily data would have reduced the estimate enhancement in canopy T. Also, in estimating canopy T the DRY plants were assumed to have the same canopy conductance as the WET plants. In reality, conductance was probably lower for the DRY than the WET plants because cotton stomata close more as ΔW increases (Xu, 2000), and therefore canopy T would not have been enhanced as much.

The results in both 1999 and 2000 indicate that eliminating or markedly reducing soil E would enhance canopy T significantly only when canopy coverage of the ground is small, and the effect is only substantial in the first several days after an irrigation. Thus, unless the soil surface is wetted by irrigation very frequently when canopy cover is small, the increase in canopy T for the season by eliminating the wetting of soil surface is likely to be minor.

**General Discussion and Conclusion**

This chapter is based both on a study of the literature and on substantial experimental work conducted at the University of California, Davis, over two years. The review of literature confirms what is generally, if vaguely, taken for granted. That is: when crop canopy cover of the soil is partial, canopy T is less than the rate of ET, and soil E is substantial when the soil surface is wet and exposed, and decreases as canopy cover increases. Although the number of reasonably definitive studies is limited, the results are fairly consistent and shows (Fig. 3) that when canopy cover of the soil is partial and soil surface wet, canopy T as a fraction of ET is not just proportional to the fractional canopy cover but greater; and soil E as a fraction of ET is not proportional to the fractional exposed soil surface but less. In other words, canopy appears to exert a disproportionately large impact on canopy T and on soil E. On the other hand, when canopy coverage of the soil is complete or very nearly so, there is still some soil E, in the order of 10 percent or less of ET.

Once the exposed soil surface begins to dry, soil E declines exponentially with time and the empirical data indicate that canopy T increases at least slightly as the result. This point is emphasized in the analysis by Ritchie (1983), of canopy T as a fraction of ET in relation to LAI. Nonetheless, the conclusion is not as firm as one would like because it is based on comparing T/ET data measured or estimated with different methods from different studies.

The experimental work conducted at Davis demonstrates clearly the influence of plant density on the speed of canopy development and hence on the extent of soil E relative to canopy T. Higher plant density and more canopy cover reduce soil E but increase canopy T. Consequently the total ET is usually increased but the amount of soil E is reduced, as demonstrated in Fig. 3 and 5. The increase in total ET caused by increased canopy T is beneficial, in that more biomass is produced by the crop per unit of ET. That is, the efficiency of consumptive water use for biomass production is improved.
Figure 10. Difference in midday (11:30 to 12:30 PST) water vapor pressure ($\Delta W$) between the foliage interior and the bulk air for the Dry and Wet cotton in 2000, and the ratio of $\Delta W$ for the Dry treatment to $\Delta W$ for the Wet treatment. Irrigation (inverted arrow heads) on 24 DAP was applied to both treatments, but subsequently only to the Wet treatment. On 85 DAP, the stand was thinned to 2.5 plants m$^{-2}$. $\Delta W$ was calculated from foliage temperature and bulk air vapor pressure.
Another aspect of the experimental work compared ET of cotton irrigated by drip with that irrigated by furrow. Without irrigation ET spikes, the pattern of daily ET over time for the drip irrigated is very different from that for the furrow irrigated (Fig. 6a). For cumulative ET over the experimental period, the data are not totally conclusive because the lysimeter of the drip irrigated treatment developed a salinity problem that slowed the growth of cotton before it was corrected. Minor adjustment of the ET data were made to account for this difference in canopy cover. Cumulative ET calculated from the adjusted data (Fig. 6c) indicates that consumptive water use of the drip irrigated treatment was essentially the same as that of the furrow irrigated treatment (436 mm vs. 426 mm). These results support the conclusions drawn in several other studies (e.g., Tarantino et al., 1982) that drip irrigation may not reduce soil E under some conditions. Drip irrigation is likely to reduce ET through the reduction in soil E in comparison to surface irrigation if one or more of the following conditions apply: (a) the time interval between drip irrigations is longer than that used in this study; (b) the time interval between furrow irrigations is shorter than that used in this study; and (c) the canopy cover develops more slowly (e.g., by planting at a lower density or by being deficient in mineral nutrients, or growing a species of crop with a slower growth rate) than that observed in this study. It is obvious that a number of other factors such as soil water holding capacity,
rooting depth, and sensitivity of the crop to low soil water status enter into consideration when deciding on irrigation intervals in addition to the potential reduction in soil E.

The extent that ET from the soil and from the crop is suppressed during sprinkler water application was also carefully assessed in many tests over the two year period in Davis. ET rate had to be calculated as the difference between the water application rate as measured by catch cans and the rate of water gain by the field as measured by precision lysimeters. Due to the fact that ET rate is small when compared to the rate of water application by impulse sprinklers, the results are quite variable. By conducting a total of nine successful tests, it is possible to conclude that ET is suppressed during the time of sprinkler irrigation, by probably 40 to 50 percent in comparison to ET from a wet field without the sprinkling. The suppression is the result of the spraying water drops from the sprinklers humidifying and cooling the air. Thus, the in-air evaporation from the falling water drops is not all vain, in that some saving of ET results. The saving is not greater because rotation of the sprinkler heads places the spray over a particular area only periodically. The general impression is that sprinkler irrigation involves extra water loss due to in-air evaporation of the drops. The extent of this evaporation has been calculated in a theoretical way, based on drop size distribution, traveling distance, and wet bulb depression as a function of air humidity. This effort should be expanded and combined with experimental measurements to better assess the in-air evaporation of sprinkler systems. The in-air evaporation rate can then be compared with the extent of ET suppression to ascertain just how much extra water is lost during sprinkler irrigations.

The final part of the experimental work was to estimate the potential increase of canopy transpiration if soil evaporation is greatly reduced or eliminated. This was done by measuring increases in foliage temperature when soil surface was dry compared to when it was wet, under conditions when canopy covered the soil only partly. Using the fact that leaf interior is essentially saturated with water vapor and the well know saturation vapor pressure vs. temperature curve, the potential effect on transpiration was estimated from the increases in water vapor gradient from the foliage to the bulk air driving transpiration. The results show that in the worst case scenario, canopy T over a dry soil surface may be 30 percent higher than over a fully wet soil surface, and the difference narrows and became insignificant as the soil surface dries over time. The common time interval between surface irrigations is in terms of a week to many days, ample time for the drying of exposed soil surface. Hence, when averaged over a period of weeks or more the difference in canopy T over a dry soil compared to a soil wetted periodically by irrigation should be considerably less. In the case we evaluated, the average difference was 17 percent for a period when the canopy cover was low. Generally speaking then, there would be some increase in canopy T when canopy cover is incomplete if soil E is essentially eliminated by irrigating with buried drip systems. The elimination of soil E, however should still result in a significant saving in total ET or consumptive water use.
References Cited


Evapotranspiration from a Satellite-Based Surface Energy Balance for the Snake Plain Aquifer in Idaho
By Richard G. Allen, Anthony Morse, Masahiro Tasumi, Ricardo Trezza, Wim Bastiaanssen, James L. Wright and William Kramer
EVAPOTRANSPIRATION FROM A SATELLITE-BASED SURFACE ENERGY BALANCE FOR THE SNAKE PLAIN AQUIFER IN IDAHO

Richard G. Allen, Anthony Morse, Masahiro Tasumi, Ricardo Trezza, Wim Bastiaanssen, James L. Wright, and William Kramber

ABSTRACT

METRIC™ (Mapping Evapotranspiration at high Resolution and with Internalized Calibration) is an image-processing tool for calculating ET as a residual of the energy balance at the earth’s surface. METRIC™ is a variant of the important model SEBAL, an energy balance model developed in the Netherlands and applied worldwide by Bastiaanssen. METRIC™ has been extended to provide tighter integration with ground-based reference ET and has been applied with Landsat images in southern Idaho to predict monthly and seasonal ET for water rights accounting and for operation of ground water models. METRIC™ has also had limited application in the Imperial Valley of Southern California. ET “maps” (i.e., images) provide the means to quantify, in terms of both the amount and spatial distribution, the ET on a field by field basis.

Results from METRIC™ have been compared and validated using precision-weighing lysimeter measurements from the U.S. Department of Agriculture – Agricultural Research Service (USDA-ARS) at Kimberly, Idaho, and from Utah State University for the Bear River. ET for periods between satellite overpasses was computed using ratios of ET from METRIC™ to reference ET computed for ground-based weather stations. ET maps via METRIC™ provide the means to quantify, in terms of both the amount and spatial distribution, ET from individual fields. The ET images generated by METRIC™ show a progression of ET during the year as well as distribution in space.

Initial application and testing of METRIC™ indicates substantial promise as an efficient, accurate, and relatively inexpensive procedure to predict the actual evaporation fluxes from irrigated lands throughout a growing season. ET from satellite images may replace current procedures used by Idaho Department of Water Resources and other management entities that rely on ground-based ET equations and generalized crop coefficients that have substantial uncertainty.

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1 This paper was originally presented at the 2002 meeting of the United States Committee on Irrigation, Drainage, and Flood Control at San Luis Obispo, CA. It has been edited and updated for republication by California Dept. Water Resources in 2004.
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8 Remote Sensing Analyst, IDWR
INTRODUCTION

METRIC™ and SEBAL represent an emerging technology that has the potential to become widely adopted and used by the world’s water resources communities. ET maps created using METRIC™, SEBAL or similar remote-sensing based processing systems will some day be routinely used as input to daily and monthly operational and planning models for reservoir operations, ground-water management, irrigation water supply planning, water rights regulation, and hydrologic studies.

In Idaho, METRIC™ has been used to generate monthly and seasonal ET maps for predicting effects of irrigation on stream flow depletion in the Bear River Basin and the upper Snake River Basin. The ET maps are also used to predict recharge to ground-water systems and to extend pumping records for ground-water diversions. The Snake River Plain aquifer system is large, spanning more than 30,000 square km (an area larger than the states of Massachusetts, Connecticut, and Rhode Island combined), with over 7,000 square km (1.7 million acres) of irrigated farmland.

Two METRIC™ applications have been made in Idaho using funding from Raytheon Company and the National Aeronautics and Space Administration (NASA). The first application, during Phase I of the study, was to the Bear River Basin of southeast Idaho (Morse et al., 2000). The second application, during Phase II, was to the eastern Snake River Plain of southern Idaho, (Morse et al., 2001).

The theoretical and computational approaches of SEBAL and METRIC™ are described in Bastiaanssen et al., (1998), Bastiaanssen (2000), Morse et al., (2000) and Tasumi et al. (2004b).

By using an energy balance at the surface, energy consumed by the ET process is calculated as a residual of the surface energy equation:

\[ LE = R_n - G - H \]  \hspace{1cm} (1)

where LE is the latent energy consumed by ET, \( R_n \) is net radiation (sum of all incoming and outgoing shortwave and longwave radiation at the surface), G is sensible heat flux conducted into the ground, and H is sensible heat flux convected into the air. The utility of using energy balance is that actual ET rather than potential ET (based on amount of vegetation) is estimated, so that reductions in ET caused by shortage of soil moisture are captured. Of course, the estimate of LE is only as accurate as the estimates of \( R_n \), G, and H. The algorithms used in METRIC™ for \( R_n \) and G are similar to those described for SEBAL by Bastiaanssen et al. (1998) and the reader is referred there and to Tasumi et al. (2004b) for detail. Basically, \( R_n \) is computed from satellite-measured broad-band reflectances and surface temperature, G is estimated from \( R_n \), surface temperature, and vegetation indices, and H is estimated from surface temperature ranges, surface roughness, and wind speed using buoyancy corrections.

METRIC™ differs from SEBAL principally in how the “H function” is calibrated for each specific satellite image. In both METRIC™ and SEBAL, H is predicted from an aerodynamic function where:
where $\rho$ is air density, $C_p$ is specific heat of air at constant pressure, and $r_{ah}$ is aerodynamic resistance between two near surface heights (generally 0.1 and 2 m) computed as a function of estimated aerodynamic roughness of the particular pixel and using wind speed extrapolated to some blending height above the ground surface (typically 100 to 200 m), with an iterative stability correction scheme based on the Monin-Obhukov functions (Allen et al. 1996). The $dT$ parameter represents the near surface temperature difference between the two near surface heights. Because of the difficulties in estimating surface temperature ($T_s$) accurately from satellite due to uncertainties in atmospheric attenuation and contamination and radiometric calibration of the sensor, $dT$ is estimated as a relatively simple linear function of $T_s$:

$$dT = a + b T_s$$  

(3)

Bastiaanssen (1995) and Bastiaanssen et al. (2004) provide rationale and empirical evidence for using the linear relation between $dT$ and $T_s$. The application of (3) appears to extend well across a range of surface roughnesses, because as roughness increases and $r_{ah}$ reduces, given the same $H$, $dT$ reduces due to more efficient transfer of $H$, and $T_s$ reduces for the same reason.

In most applications of SEBAL (Bastiaanssen et al., 1998), parameters $a$ and $b$ in (3) are computed by setting $dT = 0$ when $T_s$ is at the surface temperature of a local water body (or in its absence, a well vegetated field) where $H$ is expected to be zero, and by setting $dT = (H r_{ah})/ (\rho C_p)$ at $T_s$ of a “hot” pixel that is dry enough that one can assume that $LE = 0$. From (1) and (2), $dT = ((R_n - G) r_{ah})/ (\rho C_p)$ at the “hot” calibration pixel. In METRIC™, the same approach and assumptions are made for the hot pixel as in SEBAL, although a daily surface soil water balance is run for the hot pixel to confirm that $ET = 0$ there or to supply a nonzero value for $ET$ for the hot pixel for calibration of (3). For the lower calibration point of $dT$ in METRIC™, a well vegetated pixel having relatively cool temperature is selected and $dT$ at that pixel is calculated as:

$$dT = \frac{(R_n - G - k ET_r) r_{ah}}{\rho C_p}$$  

(4)

The $a$ and $b$ coefficients are determined using the two values for $dT$ paired with the associated values for $T_s$. With Landsat images, fields of alfalfa or other high leaf area vegetation can generally be identified that are close to or at full cover, so that the $ET$ from these fields can be expected to be near the value of “reference ET” ($ET_r$) computed for an alfalfa reference. In METRIC™, we use the standardized ASCE Penman-Monteith equation for alfalfa reference (ASCE-EWRI 2002), which is typically 20 to 30 percent greater than grass reference ET ($ET_o$). The $k$ factor in (4) is set to 1.05 because we assume that a viewed field having high vegetation and colder than average temperature, as compared to other high vegetation fields, will have $ET$ that is about 5% greater than $ET_r$ due to higher surface wetness or merely due to its rank within the population of alfalfa fields (or other highly vegetated areas). Generally, METRIC™ is applied without crop classification, so that specific crop type is generally not known.
METRIC™ and SEBAL, when applied with Landsat images, generally differ somewhat in how ET for the adjoining 24-h period is estimated given the essentially instantaneous ET calculated at the time of the satellite image (generally during late morning). In SEBAL, the evaporative fraction (EF), defined as the ratio of ET to \((R_n-G)\), is assumed to be the same at both the observation time and for the 24-h period. The assumption of constant EF can sometimes underpredict 24-h ET in arid climates where afternoon advection or increases in afternoon wind speeds may increase ET in proportion to \(R_n\). In METRIC™, the extrapolation from observation time to the 24-h period is done using the fraction of reference ET (\(ET_rF\)) rather than EF. \(ET_rF\) is defined as the ratio of ET to \(ET_r\) (in the case of METRIC™, alfalfa reference), and is essentially the same as the well-known crop coefficient, \(K_c\) (for an alfalfa reference basis). The assumption of constant \(ET_rF\) during a day may be better able to capture impacts of advection and changing wind and humidity conditions during the day, as expressed in the \(ET_r\) calculation (which is done hourly and summed daily). Trezza (2002) and Romero (2004) demonstrated the general validity of constant \(ET_rF\) during a day using lysimeter data from Kimberly.

Primary reasons why METRIC™ and SEBAL are attractive to our applications in the western U.S. are:

- METRIC™ and SEBAL calculate actual ET rather than potential ET and do not require knowledge of crop type (no satellite-based crop classification is needed).

- METRIC™ and SEBAL rely heavily on theoretical and physical relationships, but provide for the introduction and automated calibration of empirical coefficients and relationships to make the process operational and accurate.

- The use of \(ET_r\) in calibration of METRIC™ and the use of \(ET_rF\) in extrapolation to 24-h ET provides general equivalency and congruency with ET as estimated using the traditional \(K_c\) \(ET_r\) (or \(K_c\) \(ET_o\)) approach. This is valuable for use of ET maps generated by METRIC water rights management where water rights are based on previous \(K_c\) \(ET_r\) calculations.

- METRIC™ is auto-calibrated for each image using ground-based calculations of \(ET_r\) (made using weather data) where accuracy of the \(ET_r\) estimate has been established by lysimetric and other studies and in which we have high confidence.

- Internal calibration of the sensible heat computation within SEBAL and METRIC™ eliminates the need for atmospheric correction of \(T_s\) or reflectance (albedo) measurements using radiative transfer models (Tasumi et al. 2004a). The internal calibration also reduces impacts of any biases in estimation of aerodynamic stability correction or surface roughness.

**BEAR RIVER APPLICATION**

In 1958, the Bear River Compact was developed to establish how Idaho, Utah and Wyoming would equitably distribute and use water from the Bear River. The role of Idaho Department of

Water Resources (IDWR) is to compute depletion by irrigated agriculture for the Idaho part of the basin to support Idaho's position in negotiations with the other two states.

In Phase I (2000) of our study, ET maps were generated monthly for a 500 km x 150 km area (comprised of 2 Landsat images) encompassing the Bear River basin. Images were processed for 1985, coinciding with an ET study using lysimeters (Hill et al., 1989) that allowed for comparison to METRIC™. Lysimeters near Montpelier, Idaho, just north of Bear Lake, had been planted to an irrigated native sedge forage crop characteristic of the area and local surroundings. The lysimeters were measured weekly. ET from the three lysimeters was averaged to reduce random error and uncertainty in the ET measurements. Results for four satellite images during the 1985 growing season (July 14, Aug. 15, Sept. 16, Oct. 18) are summarized in Figure 1 and Table 1. The results compare well to lysimeter data for the last three image dates. The earliest date, July 14, compares well when examined in context of the impact of precipitation preceding the image date and rapidly growing vegetation during that period (Morse et al., 2000).

![ET by Lysimeters and METRIC](image)

**Figure 1.** Comparison of ET<sub>f</sub> fractions (i.e., K<sub>c</sub>) derived from 7-day lysimeter measurements near Montpelier, Idaho during 1985 and values from METRIC™ for four Landsat dates (ET = crop ET and ETr = alfalfa reference ET<sub>f</sub>).
The Fraction of Reference ET (ET_F) in Table 1 is defined as ET/ET_r where ET_r is reference ET based on an alfalfa-reference basis. ET_F values were computed for each pixel and used to extrapolate ET from the day of the satellite image to days between images. ET_F is synonymous with the well-known crop coefficient, K_c when applied to an alfalfa reference as the basis (as opposed to clipped grass ET_o). ET_r accounts for changes in ET caused by weather variation between satellite image dates.

Table 1. Summary of METRIC™ - and lysimeter-derived ET for weekly and monthly periods and the associated error for Bear River, 1985.

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<th>7-day Lys. ET ave. for image date (mm d⁻¹)</th>
<th>METRIC ETrF on image date</th>
<th>7-day METRIC ET for image date (mm d⁻¹)</th>
<th>Diff. in 7-day ET (METRIC – Lys) (%)</th>
<th>Monthly Alfalfa ET_r (mm)</th>
<th>METRIC Monthly ET (mm)</th>
<th>Lys. Monthly ET (mm)</th>
<th>Diff. in Monthly ET (METRIC – Lys.) (%)</th>
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<td>July</td>
<td>5.3</td>
<td>0.98</td>
<td>6.8</td>
<td>28%</td>
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<td>167</td>
<td>19%</td>
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<tr>
<td>Aug</td>
<td>3.5</td>
<td>0.59</td>
<td>3.7</td>
<td>6%</td>
<td>201</td>
<td>198</td>
<td>145</td>
<td>-18%</td>
</tr>
<tr>
<td>Sept</td>
<td>1.9</td>
<td>0.57</td>
<td>2.1</td>
<td>10%</td>
<td>115</td>
<td>63</td>
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</tr>
<tr>
<td>Oct</td>
<td>0.7</td>
<td>0.49</td>
<td>0.6</td>
<td>-14%</td>
<td>45</td>
<td>22</td>
<td>23</td>
<td>-5%</td>
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<tr>
<td>July-Oct</td>
<td>2.9</td>
<td>0.73</td>
<td>3.3</td>
<td>15%</td>
<td>563</td>
<td>405</td>
<td>388</td>
<td>4%</td>
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</table>

Predicted monthly ET averaged +/- 16% relative to the lysimeter at Montepelier (Table 1). However, seasonal differences between METRIC™ and lysimeters were only 4% due to impacts of reduction in the random error component present in each estimate.

**SNAKE RIVER PLAIN APPLICATION**

Managing water rights and irrigation on the Snake River Plain and tributary basins presents a challenge to IDWR. Water for irrigation comes from surface and ground sources. For various historical reasons, the use of surface water has been directly measured and regulated by IDWR while the use of ground water has not. This situation began to change in 1995 when the Water Measurement Information System Program was established within IDWR to measure groundwater use. IDWR has dedicated considerable resources to water measurement, including three full-time positions to monitor about 5,000 points of diversion, mostly wells. As useful as these data are, they do not provide all the information necessary for effective management of the resource, nor do they include all irrigation wells. Information regarding the ET or consumed fraction of diversions is needed. METRIC™ or SEBAL can be used in conjunction with Water
Measurement data in an efficient program to help manage water development, use and stewardship. METRIC™ and SEBAL cover large areas inexpensively and efficiently, thereby extending Water Measurement data in both time and space, and the Water Measurement data, in turn, can be used to calibrate relationships based on METRIC™ or SEBAL results.

This combined program offers advantages over present methods: 1) it offers the ability to monitor whether water has actually stopped being used for irrigation after a water shut-off order has been issued; 2) it can discover if more water has been used than authorized; 3) it can quantify and be used as proof of beneficial use of a right; 4) it can be used as an unbiased, quantitative record of historical use; 5) the consumed fraction and return of non-evapotranspired water to the resource can be quantified; 6) estimates of yield and productivity can be made to assess benefits of water development and tradeoffs in water management. In addition, resulting seasonal ET maps are utilized by the State of Idaho, University of Idaho, and U.S. Bureau of Reclamation ground-water modelers to predict recharge of irrigation water to the Eastern Snake Plain Aquifer.

A number of tasks during Phases II - IV (2001-2003) were directed at improving components of METRIC™ to better predict ET for environments found in the western United States. These include prediction of net radiation and soil heat flux components and identification and assessment of the energy balance for “anchor” pixels used to define the overall energy balance for the image. Other improvements included determination of mean wind speeds in mountain areas, prediction of aerodynamic roughness for various vegetation covers, and development of an ET reference fraction (ET$_r$F) approach for extending ET between images (Allen et al., 2001).

The production of ET maps having 30 m resolution for the Eastern Snake River Plain Aquifer was highly successful. ET images were created for 12 dates during 2000 and were integrated over the March – October period. Interpolation between image dates was done using ET$_r$F from pixels of each image and multiplying these by ET, computed for each day between images.

Images were purchased from both Landsat 5 and Landsat 7 archives for 2000 to increase the number available for the southern Idaho area. Often, dates for adjacent Landsat 5 and 7 paths were separated by just one day. Landsat 5 images were of immense value in providing ET for similar periods between paths. Algorithms were developed to correct individual reflectance bands of Landsat 5 to coincide with measurements by Landsat 7 to account for sensor deterioration.

**Validation of METRIC at Kimberly, Idaho**

The validation of METRIC™ on the Snake River Plain has centered on the use of two precision-weighing lysimeter systems for ET measurement in place near Kimberly, Idaho, from 1968 to 1991. The lysimeter system was installed and operated by Dr. James Wright of the USDA-ARS (Wright, 1982, 1996) and measured ET fluxes continuously. ET data are available for a wide range of weather conditions, surface covers, and crop types. Measurements of net radiation, soil heat flux and plant canopy parameters were frequently made near the lysimeter site. The lysimeter data sets provided valuable information to verify METRIC™ over various time scales and for various conditions of ground cover.
Crop Water Use

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Nineteen Landsat 5 satellite image dates were purchased for Kimberly, Idaho, covering the period between 1986 and 1991. These dates had quality lysimeter and cloud-free micrometeorological data and represent a combination of crop growth stages and times of the year. Eight images from 1989 are discussed here.

The lysimeter data for intervening periods between image dates were used to assess the impact of various methods for extending ET maps from a single day to longer periods. They have also been used to assess the variability in ET_rF over a day. The success of METRIC™ is predicated on the assumption that ET_rF for a 24-hour period can be predicted from the ET_rF from the instantaneous satellite image. ET_r was calculated for hourly and 24-hour periods using the ASCE standardized Penman-Monteith method for an alfalfa reference (EWRI, 2002), representing the ET from a well-watered, fully vegetated crop, in this case, full-cover alfalfa 0.5 m in height. The denominator ET_r serves as an index representing the maximum energy available for evaporation.

Weather data were measured near the lysimeter and included solar radiation, wind speed, air temperature and vapor pressure. Lysimeter data analyses showed ET_rF = ET / ET_r to be preferable to the evaporative fraction (EF) parameter used in some applications of SEBAL (Bastiaanssen et al., 1998, Bastiaanssen 2000), where EF = ET / (R_n – G). The better performance by ET_rF was due to its consistency during daytime and agreement between hourly ET_rF at satellite overpass time (~1030) and daily average ET_rF. An illustration of ET_rF for a day in 1989 is given in Figure 2 for clipped grass (alta fescue) and sugar beets. ET_rF for many days was even more uniform than shown in the figure. In nearly all cases, the ET_rF for the 24-hour period was within 5% of the ET_rF at 1030.

Table 2 summarizes error between METRIC™ and lysimeter measurements during 1989, a year when a significant number (eight) of both lysimeter measurements of ET and Landsat images were available. Absolute error averaged 30% for the eight image days. When April 18 was omitted, the average absolute error was only 14%. April 18 was before planting of the sugar beets and represented a period of drying bare soil following precipitation. The field at this time was nonuniform in wetness due to differential drying, and differences between lysimeter and estimate were only 1 mm. The standard deviation of error between METRIC™ and lysimeter for dates from May – September was 13%. In comparison, a commonly quoted standard error for ET prediction equations that are based on weather data, for example, Penman or Penman-Monteith-types of equations, is about 10% for daily estimates. METRIC™ was able to obtain close to this level of accuracy for the field surrounding the lysimeter. Results are illustrated in Figure 3, where ET is expressed in the form of ET_rF. ET_rF was used to normalize results for differences in climatic demand (i.e. ET_r). The round symbols and horizontal line segments in Figure 3 represent ET_rF determined from lysimeter on the image date, only. These values are those directly comparable with METRIC™ predictions in Table 2. The triangular symbols in represent the ET_rF predicted by METRIC™ for the image date.

Table 2 summarizes the extrapolation of ET by METRIC™ over the season (April 1 – Sept. 30, 1989). Most periods were 16 days, centered on the image date. April 18 was used to represent April 1 – April 25, July 23 was used to represent July 16 to August 24 and Sept. 25 was used to represent Aug. 25 through Sept. 30. What is surprising is the close agreement for seasonal ET for April 1 – September 30. The difference between METRIC™ (714 mm) and the lysimeter measurement (718 mm) was less than 1% for the sugar beet crop. It appears that much of the
error occurring on individual dates was randomly distributed, and tends to cancel, as described in more detail in Allen et al., (2004).

Figure 2. Hourly measured ET, ET_r, ET_rF and 24-hour ET_rF for July 7, 1989, for clipped grass (top) and sugar beets (bottom) at Kimberly, Idaho.
Table 2. Summary and computation of ET during periods represented by each satellite image and sums for April 1 – September 30, 1989, for Lysimeter 2 (Sugar Beets) at Kimberly, Idaho.

<table>
<thead>
<tr>
<th>Image Date</th>
<th>Lys. ET on date (mm d⁻¹)</th>
<th>METRIC ET on date (mm d⁻¹)</th>
<th>Error on Image Date (%)</th>
<th>ETᵣ on date (mm d⁻¹)</th>
<th>ETᵣ for period (mm)</th>
<th>Lys. ET summed daily for period (mm)</th>
<th>Lys. ET for period based on image date only (mm)</th>
<th>METRIC ET for period (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/18/89</td>
<td>0.73</td>
<td>1.74</td>
<td>139</td>
<td>6.78</td>
<td>147</td>
<td>28</td>
<td>16</td>
<td>38</td>
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<tr>
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<td>6.61</td>
<td>5.09</td>
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<td>7.76</td>
<td>94</td>
<td>30</td>
<td>80</td>
<td>62</td>
</tr>
<tr>
<td>5/20/89</td>
<td>1.37</td>
<td>1.34</td>
<td>-2</td>
<td>7.27</td>
<td>90</td>
<td>22</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>6/5/89</td>
<td>1.73</td>
<td>1.78</td>
<td>3</td>
<td>6.68</td>
<td>118</td>
<td>24</td>
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<td>31</td>
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<tr>
<td>6/21/89</td>
<td>2.39</td>
<td>2.54</td>
<td>6</td>
<td>6.33</td>
<td>127</td>
<td>62</td>
<td>48</td>
<td>51</td>
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<tr>
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<td>7.96</td>
<td>5.89</td>
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<td>116</td>
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<tr>
<td>7/23/89</td>
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<td>-6</td>
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<td>171</td>
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<td>186</td>
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<td>4/1– 9/30</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

| Percent Error | 718ᵃ | 705ᵇ | 714ᶜ |

ᵃ The sum of daily measurements by lysimeter computed as the sum over all days between April 1 and Sept. 30.
ᵇ The sum of ET computed for each lysimeter period, computed by multiplying summed ETᵣ during the period by the ETᵣF for the image date.
ᶜ The sum of ET predicted by METRIC™ for the lysimeter 2 field, computed by multiplying the summed ETᵣ during the period by the ETᵣF computed on the image date by METRIC™.

An illustration of the type of resolution for ET maps generated from Landsat imagery is shown in Figure 4 for a 4 km x 6 km area near American Falls, Idaho.

**IMPERIAL VALLEY**

Evapotranspiration maps were created using METRIC™ and Landsat 7 images for much of Imperial Valley, California, for the January-March periods of 2002 and 2003 (Allen et al., 2003). The application demonstrated the ability to produce maps of quantitative, spatial distribution of monthly ET in near real time with resolution on the sub-field scale.

**IMPACT**

The METRIC™ work is evolving. Nevertheless, there have been impacts. IDWR found the results of Phase I and II sufficiently compelling to request additional funding from the Idaho Legislature to include METRIC™ as the ET source for recalibration of the Eastern Snake River Plain aquifer model and to generate ET maps to monitor ground-water pumage. The aquifer model uses 5 km grid cells, and aggregating ET up to a 5 km cell is preferable to disaggregating county-averaged data.
Figure 3. Results by METRIC™ and ET by Lysimeter as ET$_F$ (top). The thin line is the five-day average ET$_F$ for lysimeter and the thick line is the assumption used in that application to extrapolate between images. The bottom figure shows total ET for the image period.
COST SAVINGS

ET data derived from METRIC™ are less expensive to generate than are standard ET data. Since IDWR is still developing the METRIC™ data, a quantitative cost-benefit analysis is premature. Nevertheless, it is possible to do a rough cost comparison based on some available figures.

Current costs for monitoring water use on the eastern Snake River Plain are estimated to be about $500,000 per year. We estimate costs for remote sensing to be about $100,000 per year. This includes costs for 30 TM scenes representing 8 to 10 dates for the whole eastern Snake Plain (Landsat scenes cost about $400 each for images. Geo-registration of images costs an additional $400 each, for a total procurement cost of about $24,000, and about three Landsat images (100 miles x 100 miles) are required to cover the full area). Once set up for an area, METRIC™ processing requires about 8 days per scene (240 days * 8 hours = 1920 hours * $40.00 per hour = $76,800 for processing for the full year for the full eastern Snake Plain). The total for remote sensing is therefore about $100,000. Set-up and time for aggregation of ET results via GIS results in a total remote sensing cost of about $105,000. Using these figures, the estimated cost ratio of remote sensing to the current measurement program is $105,000/$500,000 = 0.21, i.e., remote sensing costs about 20% of the measurement costs. Measurement costs are for a subset of the total number of wells, all of which are not measured in a single year, whereas,

Figure 4. Close-up of ET (left) with false color composite (right) from Landsat 7 showing variation within individual fields May 5, 2000.
METRIC™ data cover the entire Snake River Plain and all places of use. The use of METRIC™ ET will not replace the existing measurement program, per se. Pumpage data that can be related to individual water rights will be needed for regression against the METRIC™ ET data for the same water rights to establish the relationship between volume pumped and volume of ET. That relationship can then be applied to all other non-monitored water rights and their associated wells to estimate both aquifer depletion and water use by individual water rights.

**SUMMARY AND CONCLUSIONS**

METRIC™ and SEBAL use digital image data collected by Landsat and other remote-sensing satellites that record thermal infrared, visible and near-infrared radiation. ET is computed on a pixel-by-pixel basis for the instantaneous time of the satellite image. The process is based on a complete energy balance for each pixel, where ET is predicted from the residual amount of energy remaining from the classical energy balance, where $ET = \text{net radiation} - \text{heat to the soil} - \text{heat to the air}$.

In Phase 1 for the Bear River Basin, the difference between METRIC™ (derived from SEBAL) and the lysimeter, total, for the growing season was 4%. For the Phase 2 comparison with precision weighing lysimeters at Kimberly, differences were less than 2%. These comparisons represent a small sample, but are probably typical. Error as high as 10 to 20%, if distributed randomly, could probably be tolerated by IDWR and by the water user communities.

Comparisons of METRIC™ predicted ET with precision weighing lysimeter data at Kimberly, Idaho from the 1980’s and early 1990’s have provided valuable information on the conditions required to obtain maximum accuracy with METRIC™ and the best procedure for obtaining ET monthly and annually. ET has been calculated for the entire Snake River Plain of southeastern Idaho and has improved the calibration of ground-water models by providing better information on ground-water recharge as a component of water balances. Ground-water pumpage from over 10,000 wells has been estimated using ET from METRIC™ by developing correlations between ET and pump discharge at measured wells and then extrapolating over large areas using ET maps from METRIC™.

**REFERENCES**


2002 USCID/EWRI Conference


Limits to the Productivity of Water in Crop Production
By Andrew Keller and David Seckler
Limits to Increasing the Productivity of Water in Crop Production

Andrew Keller and David Seckler

The dramatic increase in world food production over the past half century has been from increased crop yields. It is generally agreed that future increases in world food production will become even more dependent on increased yields as the amount of cultivated area in the world continues to decrease. Increased yields have been accompanied by increased water productivity through a variety of factors discussed below. However, we contend that in most of the advanced agricultural areas of the world, which produce most of the world's food, the historic sources of growth in water productivity are being rapidly exhausted and there is very little of practical significance on the horizon to replace them. Thus, it is not at all clear how the increased yields are to be achieved. We shall not attempt to summarize all the various issues involved in this question here. Rather we shall concentrate on one fundamentally important question that has not received sufficient attention in our judgment. The question is: “Will increased crop yields simultaneously create increased water scarcity because of increased transpiration?”

Given the fact that transpiration is typically most of the total consumptive use of water by crops, this question has enormous implications for the future of irrigation and food production. It means that increased production through increased yields could create its own, formidable, constraint in terms of water scarcity. It also means that the potential for increasing water productivity through increased yields may be severely limited.

This question was posed in early 2004 by one of the present writers. It stimulated an email discussion among several leading authorities in the field of irrigation and plant-water relationships. The discussion revealed wide areas of disagreement. Further research and consultation with other authorities revealed that the answer to this question depends on several factors. In this section of the paper we attempt to answer this question in relation to the various factors involved.

The first, fundamental and somewhat controversial factor to consider is the relationship between water use and crop yields. Thinking about this relationship is complicated and confused by the failure to clearly distinguish between three basic categories of plant-water relationships: transpiration, evaporation and drainage (TED). Because of the importance of getting this relationship correct, a considerable amount of space, in rather technical language, is devoted to it in the next section.

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1 This paper is an extract from a manuscript under review for publication in a special issue of *Irrigation Science*. Comments on the paper in the Forum section of Winrock Water would be appreciated.

2 Brief biographies of the authors are in the Board of Editors section of Winrock Water.

3 We have attempted a brief layman’s description of the process of transpiration in Appendix A.

4 This question mainly grew out of an earlier study of transpiration by the authors, see Seckler, 2003.
Transpiration, Evaporation, Drainage and Yields

Figure 1 shows the idealized relationship between relative crop yield ($Y_{rel}$) and total available seasonal water (available soil water + rainfall + irrigation) componentized into $T$, $E$, and $D$. The figure begins on the left hand side with the relative yield to transpiration relationship.

The X-axis in Figure 1 is the total available water relative to the seasonal transpiration potential, $T_P$ (water not limiting). The short-dashed curve in the figure represents the total evapotranspiration, $ET = T + E$, relative to $T_P$ and has a maximum value of $ET/T_P$, which is greater than or equal to 1.0 depending on the amount of $E$. The solid curving rightmost line represents the total available water and corresponds to the total consumed water ($ET$) plus drainage ($D$) relative to $T_P$. (Note that here drainage includes surface runoff as well as subsurface drainage from rainfall and irrigation.) At low levels of available water $D$ may be zero as all available water is consumed by $ET$. The relative yield as a function of available water, $ET + D$, reaches a maximum of 1.0 and then begins to decline due to water logging and the leaching of nutrients as excessive amounts of water are applied.

The difference between the solid line and the short-dashed ET line, drainage ($D$), represents the “losses” due to “inefficient” (i.e., over) irrigation and untimely rainfall. To the extent that these losses are not consumed by non-beneficial evaporation, do not flow to salt sinks, and do not cause water logging or nutrient leaching, they are inconsequential from a water conservation standpoint, since they remain somewhere in the fresh water resource; however, they may represent wasted labor and energy (see Molden, et.al., 2001).

Rainfed crop production and different irrigation technologies will have different evaporation and drainage characteristics, but the yield-T relationship will be constant for a given crop and climate. For example, subsurface drip irrigation may not have any evaporation loss after germination, in which case the ET curve would be offset from the T curve by the amount of the initial evaporation loss and parallel to it. If there were no drainage water, the ET+D curve would be coincidental with the ET curve.

Charles Burt and associates at CalPoly (2001) estimated the $T$ and $E$ components of ET following the FAO 56 dual crop coefficient method for various types of irrigation systems and irrigated areas of California. While the approach was more theoretical than empirical, and not highly analytical, relative comparisons are probably reasonable. The interesting conclusion is the very small difference in total ET between furrow, sprinkle, and subsurface drip irrigation (SDI). What varies more is the partitioning of ET into $T$ and $E$, with SDI having the least evaporation loss of applied irrigation water (4% of seasonal ET) and sprinkle irrigation having the most (8% of ET).

---

5 The ET curve shown here assumes $E$ increases slightly with increasing $T$. In actuality $E$ may decrease at higher levels of $T$ due to the increased shading of the ground resulting from more crop biomass associated with greater $T$. Indeed this is the conclusion from the analysis described in Appendix B. However, it should be noted that $E$ is quite variable depending on the timing or irrigation and rainfall and the method of irrigation, among other factors.

6 Implicit here is the assumption that the water available for transpiration is more or less uniformly distributed through out the growing season such that there are no concentrated periods of extreme drought.
If the drainage water, $D$, is recoverable for use elsewhere, the maximum crop water productivity is obtained at the point on the ET curve that is tangent to a line running from the origin to the ET curve as depicted by the O-E line in Figure 1. ET greater than this point of tangency has a declining return to consumed water. Likewise, if the drainage water is not useable elsewhere, and thus is a true loss, the maximum return to water occurs at the point on the ET+D curve that is tangent to a line running from the origin to the curve as depicted by the O-D line in Figure 1.

From a farmer’s perspective drainage water is generally a loss so the optimal position is to deficit irrigate. This is particularly true with uncertain rainfall and unreliable irrigation deliveries, which motivate farmers to greatly under-irrigate. “Where a farmer has uncertain rainfall (but often less than required to mature a crop), and inadequate irrigation water to bridge the gap between rain and full ET for his holding, he will seriously under-irrigate to ensure that he captures the maximum value from the free rainfall (which is a function of area cropped).” (Perry, 2002) Thus, policies that lead to unreliable irrigation deliveries result in suboptimal return to water at the basin level even if the drainage water is reused.

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7 Because the nature of the ET curve, maximum crop water productivity will generally occur at maximum ET.

8 At the farm level greater total yield can be obtained by somewhat deficiently irrigating a larger area than by fully irrigating a smaller area using the same total volume of irrigation water. However, this does not necessarily mean that the maximum economic return is at a yield point less that $Y_P$ because the input costs associated with irrigating a large area may offset any gains in total yield. Also the risks associated with deficit irrigation are greater than those with full irrigation, so the expected value yield may actually be less.
Crop Water Productivity

Our literature review has found inconsistent use of the terms transpiration efficiency (TE) and crop water use efficiency (WUE), which has caused some confusion for us and we suspect others on this subject. Furthermore, calling these efficiency terms is misleading because doing so implies causality, i.e. crop yield is the result of water consumption. This misconception is perpetuated by plotting crop yield as the ordinate versus evapotranspiration as the abscissa and by expressing crop yield as a function of evapotranspiration.

In actuality, as explained earlier, water consumption in the form of transpiration occurs as a cost of crop growth. When a plant’s stomata open to allow assimilation of CO₂, water is lost. The amount of water loss per unit biomass gain is dependent primarily on characteristics of the plant and the humidity of the plant’s environment.

We define TE as the crop aboveground (aerial) biomass divided by the volume of water transpired during the accumulation of that biomass. WUE is the aerial crop biomass divided by the volume of water transpired and evaporated in association with the production of that biomass. We have adopted the term crop water productivity (CWP) after Kinje, et al. (2003) and Zwart and Bastiaanssen (2004) to refer to the economic (grain, fruit, lint, etc.) yield divided by the volume of water consumed (evapotranspiration) in the production of that yield. TE, WUE, and CWP are all expressed in kg per m³.

The inclusion or exclusion of evaporation in the yield-water relationship is crucial. We contend that, when normalized for Δe, transpiration (T) and aerial biomass (aboveground dry matter yield, Y_dm) are essentially proportional according to a crop specific constant. In other words, TE, adjusted for Δe, is more or less constant for a crop (Eq. 1). It is the evaporation (E) component of evapotranspiration (ET) that introduces non-linearity and most variability in the yield-water relationship.

\[
TE' = \frac{Y_{dm}}{T'} = \frac{Y_{pdm}}{T_P}
\]  

Equation 1

- Plants and humans experience humidity differently. For humans it is the relative humidity that affects our comfort. The critical aspect of humidity from a plant’s standpoint is the difference in vapor pressures inside and outside the leaf. This difference is the governing force for transpiration and is closely approximated by the vapor pressure deficit of the air outside the leaf. The vapor pressure deficit (Δe) is the difference between the saturation vapor pressure (e₄), which is temperature dependent (increasing exponentially with temperature), and the actual vapor pressure of the air (e), which is dependent on the amount of water vapor in the air and independent of temperature. Relative humidity (RH) is the ratio of e to e₄, expressed as a percent: RH=100 e/e₄. Thus, Δe can be calculated from RH: Δe=e₄(1-RH/100). Pressure is a force per unit area and is typically expressed in Pascals (Pa) or bars.

- TE and WUE might be thought of as benefit-cost ratios (yield-ET) rather than efficiencies. Viewed this way we marvel at how plants optimize growth within the constraints of their environment, whereas if we look at them from an efficiency standpoint we might see them as rather inefficient. Plant scientists use the term transpiration ratio to refer to the amount of transpiration associated with biomass production, thereby avoiding the potential confusion associated with efficiency. But TE, which is essentially the reciprocal of the transpiration ratio, is also widely used by plant scientists and others. As this is a paper concerning crop water use we find ourselves generally referring to TE. Rather than inventing new terminology we have chosen to continue with TE and WUE.

- Throughout this paper we use aerial biomass and aboveground dry matter interchangeably.
TE, T', and T_P in Eq. 1 are the transpiration efficiency, transpiration, and potential transpiration respectively, normalized for \( \Delta e \)\(^{12} \), and Y_d and Y_P are respectively the aerial biomasses associated with T and T_P.

Bierhuizen and Slatyer (1965) proved that TE was linked to the vapor pressure deficit (\( \Delta e \)) and derived the following broadly accepted (Tanner and Sinclair, 1983; Howell, 1990a; Ehlers and Goss, 2003) relationship:

\[
TE = \frac{k}{\Delta e} \tag{Eq. 2}
\]

Expressing TE in Mg ha\(^{-1} \) mm\(^{-1} \), the k factor has the units of Mg ha\(^{-1} \) mm\(^{-1} \) Pa. Since the mass of 1 ha-mm of transpired water is 10 Mg, the k factor can be expressed simply in Pa. Table 1 is adapted from Ehlers and Goss (2003) to illustrate k factors\(^{13} \) for various C\(_4 \) and C\(_3 \) crops. Although Table 1 does not show it there is some variability in k factors for a crop and an apparent slight increase with increasing \( \Delta e \). (See Tanner and Sinclair, 1983; Howell, 1990a; and Ehlers and Goss, 2003 for further discussion.)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Type of CO(_2) fixation</th>
<th>k (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum</td>
<td>C(_4)</td>
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</tr>
<tr>
<td>Maize</td>
<td>C(_4)</td>
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<td>Oat</td>
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<tr>
<td>Potato</td>
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</tr>
<tr>
<td>Lucerne</td>
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<td>Soybean</td>
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<td>Pea</td>
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<tr>
<td>Faba bean</td>
<td>C(_3)</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Using the methods of FAO Irrigation and Drainage Paper No. 56 (hereafter FAO 56), crop potential transpiration is assumed to be approximately equal to the basal crop evapotranspiration, ET\(_{cb}\):

\[
T_P \approx ET_{cb} = K_{cb} ET_o \tag{Eq. 3}
\]

Where K_{cb} is the basal crop coefficient and ET_o is the reference evapotranspiration. K_{cb} is crop specific and varies with the leaf area of the crop relative to the ground area (leaf area index, LAI)\(^{14} \). The LAI is primarily a function of the crop biomass.

T is less than or equal to T_P depending primarily on the degree of water stress. The concept of crop water stress is nicely introduced by the following from FAO 56:

*Forces acting on the soil water decrease its potential energy and make it less available for plant root extraction. When the soil is wet [and salinity low], the water has a high potential energy, is relatively free to move and is easily taken up by the plant roots. In dry soils [or when enough salts are present in the soil water solution], the water has a low potential energy and is strongly bound by capillary and absorptive forces to the soil matrix, and is less*

\(^{12}\) T is normalized for humidity by multiplying by a reference \( \Delta e \) (i.e., 1 kPa) divided by the mean daytime \( \Delta e \).

\(^{13}\) Note that at \( \Delta e \) of 1 kPa the k factor is numerically equivalent to TE expressed in kg m\(^{-3}\).

\(^{14}\) Typical K_{cb} values for the initial, mid-season, and ending growth stage for maize are 0.15, 1.15, and 0.15 respectively. A typical value for cool season turf grass is 0.9.

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\( T \) is less than or equal to \( T_P \) depending primarily on the degree of water stress. The concept of crop water stress is nicely introduced by the following from FAO 56:

*Forces acting on the soil water decrease its potential energy and make it less available for plant root extraction. When the soil is wet [and salinity low], the water has a high potential energy, is relatively free to move and is easily taken up by the plant roots. In dry soils [or when enough salts are present in the soil water solution], the water has a low potential energy and is strongly bound by capillary and absorptive forces to the soil matrix, and is less*
easily extracted by the crop. When the potential energy of the soil water drops below a threshold value, the crop is said to be water stressed. The effects of soil water stress on transpiration are described by multiplying Eq. 3 by the water stress coefficient, $K_s$:

$$ T = K_s T_p = K_s ET_{ch} = K_s K_s ET_v \quad \text{Eq. 4} $$

$K_s$ is less than 1 when there is water stress, i.e., limited availability of low salinity soil water, and equal to 1 when there is no water stress. From Eq. 1 and Eq. 4 it is apparent that the relative dry matter yield ($Y_{\text{Rel dm}} = Y_{dm} / Y_{P dm}$) equals the relative transpiration ($T_{\text{Rel}} = T / T_p$), which equals $K_s$.

Total crop biomass includes all dry matter in the roots, stems, leaves, and fruit (or grain) of the crop. Figure 2 shows the accumulation of total aboveground maize plant biomass (non-fruit plus fruit) by phenological stage and days since emergence (adapted from Ritchie, et al., 1993). Once

![Figure 2. Total aboveground maize plant biomass (non-fruit plus fruit) by phenological stage and days since emergence.](image-url)
the 18-leaf (V18) stage, corresponding to early tassel and 40% of total mature plant dry matter, is reached, dry matter accumulation proceeds at a nearly constant rate. Accumulation of dry matter in the maize kernels begins at silk (R1) stage, which is about the midpoint in the growing season and total dry matter accumulation, and continues to maturity. Note that during the final reproductive stages dry matter accumulation in the grain comes, in part, from the non-grain portion of the plant.

The harvest index is typically defined as the harvested fraction of a crop at maturity. For grain crops the harvest index is the dry matter of the grain yield divided by the aboveground biomass. The lower portion of Figure 2 shows the harvest index and the non-fruit portion of the total aboveground biomass.

Howell (1990b) and others have suggested a linear relationship between grain yield, $Y_{gr}$, and aerial dry matter yield, $Y_{dm}$, as follows:

$$Y_{gr} = b(Y_{dm} - a)$$

where $a$ and $b$ are crop specific constants and $b$ can be thought of as the asymptotic harvest index and $a$ as the dry matter required for a harvested yield. Equation 5 appears to be valid over a wide range of $Y_{dm}$ and independent of water stress, but dependent on plant density. The relationship between grain yield, harvest index, and aerial dry matter is depicted in Figure 3 using values referenced by Howell (1990a) of 0.49 and 2.47 for $b$ and $a$ respectively in Eq. 5.

It is important to note that Figure 2 is for non-stressed conditions. When a plant is stressed it often enters into the reproductive stages early. But whether this changes the harvest index depends upon the timing of the stress among other factors. For our purposes here we assume that the relationship between total plant biomass and the accumulation of biomass in the fruit is similar to that shown in Figure 2, and idealized by the linear relationship of Equation 5, under both stressed and non-stressed conditions. However we recognize that with maize, particularly, stress during the V18, R1 and adjacent stages can cause disparity between the timing of tasseling and silking for some cultivars, thereby reducing pollination effectiveness and thus yield potential.

Figure 4 shows the aerial dry matter accumulation with time, relative to the seasonal total, from Figure 2 plotted against the relative cumulative long-term (20-year) average growing season ET for Iowa\textsuperscript{16} (Shaw and Newman, undated). The linear regression line in Figure 4 demonstrates a near one to one relationship between relative biomass and relative ET.

\textsuperscript{16}The reference does not give the actual years or locations in Iowa used to compile the average or the method of measuring or estimating ET.
Yield-ET data from multiple locations combined into a single plot have much more scatter than in Figure 4, often to the extent that they may initially appear to indicate there is little correlation between yield and ET. We content, however, that this apparent lack of correlation is due primarily to two factors: 1) the data, coming from several different locations, likely have different associated Δe and thus TE; and 2) as stated earlier, the E part of ET is what introduces most of the noise in the yield-ET relationship once the data have been normalized for Δe. To demonstrate these points we conducted the analysis presented in Appendix B and arrived at an important and interesting conclusion—CWP is maximized by full irrigation of a smaller area rather than by deficit irrigation of a larger area with the same volume of water. The reason is that E relative to total seasonal ET decreases as T increases. Thus, maximizing crop yield is compatible with maximizing CWP.

If the estimated E in the Appendix B analysis were reduced by half and moved to T, grain yields would increase by an average of nearly 30% with no change in total consumptive use. As long as ET is unchanged there would be no change in vapor pressure deficit around the surface of the leaves so the transpiration efficiency would remain constant and yields would increase proportional to the increase in T. However, if E were reduced without somehow shifting the reduction to T, i.e., if the total ET were reduced\textsuperscript{17}, there would be a potential increase in Δe and a coincidental decrease in transpiration efficiency and crop yield. We conducted a quick analysis to evaluate this offsetting effect of reducing E and concluded that, under reference conditions, T would have to increase by up to 30% of the amount of E-reduction to obtain the same pre-E-reduction crop yield. State another way, 30% or less of E is beneficial from the standpoint of lowering Δe and thereby increasing transpiration efficiency. Accordingly, net water savings from reducing E without an equivalent increase in T are at least 70% of the E-reduction. Under windy conditions the net savings would be even greater.

**Will increased yields increase water scarcity?**

Now we return to the original question in the title of this section. At first blush, the answer seems straight-forward. The close linear relation between yield and transpiration demonstrated in the preceding section means that an increase in yield is *ipso facto* accompanied by a proportionate increase in transpiration. However, this does not necessarily mean that there is a proportionate increase in water consumption. There several factors to consider in the relationship between transpiration and water consumption.

\textsuperscript{17} Reducing E without a corresponding increase in T seems rather unlikely since water saved by reducing E, whether it be through mulching, weeding, or change in irrigation method, would most likely be available for T.
The first factor to consider is that the linear relationship between yield and transpiration relates to yield of total plant biomass. While nearly everyone agrees on this relationship, the situation obviously changes when yield is defined in terms of only part of the biomass—the seeds and other components of the “economic yield.” The economic yield can be increased without increasing the total biomass and, therefore, without increasing transpiration.

A substantial amount of the growth in crop yields over the past few decades has been due to plant breeders’ partitioning plant biomass toward economic yield and away from the shoots and other components of total biomass—in other words, by increasing the “harvest index” (HI). While increasing HI was done primarily to increase economic yields it simultaneously provided something of a free ride in terms of water consumption. Since the total biomass per unit area did not change, transpiration remained the same with increased economic yield.

However, the free ride provided by increasing HI may be ending. “Since about 1980, only minor increases in the harvest index have been achieved…it appears unlikely that further major yield increases in cereals can result from further major increases in HI.” (Sinclair and Gardner, 1998) This conclusion is confirmed in Zwart and Bastiaanssen (2004), whose data show that crop water productivity for wheat, rice, and maize has not changed appreciably in twenty-five years. Bennet (2003) also seems to agree with this view, giving increased HI only a moderate ranking in his survey of genetic opportunities for increasing water productivity.

A second factor to consider is the effect of increasing plant densities per unit area on water consumption. Sinclair and Gardner (1998) list this as another, perhaps the most important, source of growth in food production over the past few decades. Since increased plant densities increase total biomass per unit area, total transpiration per unit area would increase in proportion. However, as noted before, increased plant densities also decrease evaporation losses from the soil. Thus total evapotranspiration would not increase proportionately and some of the reduced evaporation losses would be partitioned over to transpiration.

A third factor in increasing yields is improved nutrient supply to the plant though more and better fertilizers. It is generally agreed that when there is severe nutrient scarcity to the plant but sufficient water availability, the TE of the plant decreases. Thus better fertilization will increase TE. This does not however negate the fact that total transpiration will increase along with the increased yield. Also, it is generally agreed that the effect of increased TE with better nutrient supply occurs only with severe nutrient scarcity—where the yield is below 40%-50% of where it would have been with adequate nutrients. Above this level, TE is constant (Tanner and Sinclair, 1983). Indeed, Euler and Goss (2003, p. 152) end their chapter on this subject by saying, “We can conclude that TE is largely independent of the fertility status of the soil” (their italics).

Fourth, there is the complex and presently unknown potential of crop breeding and molecular biology for increasing TE. The differences in TE between C3, C4 and CAM species discussed Appendix A. It is also known that different varieties of the same crop differ somewhat in TE and means have been devised to screen crops for the traits associated with these differences. We will not discuss this subject further here except to say that perhaps most authorities range from deep skepticism (Tanner and Sinclair, 1983) to slight optimism (Bennett, 2003) on the potential for substantial advances in this direction.

Fifth, there is one way to attain large increases in food production with lower or even substantially reduced total transpiration about which everyone does agree. This is by relocating crop production (and/or crop growth periods) to areas (and times) with lower evaporative...
demand for water (see the interesting discussion of this and other alternatives in Tanner and Sinclair, 1983). By this simple expedient, TE of the relocated crops could be increased several fold. This is the underlying logic behind the concept of virtual water, discussed in Part I, and there is little question that as water scarcity becomes increasingly severe in many regions of the world, international trade will gradually reflect the comparative advantages of different regions of the world in terms of water demand and supply.

In sum, it appears to us that, barring major genetic breakthroughs and relocating crops in place and time, the major opportunities for increasing yields without increasing total water consumption lies in the three areas of: a) reducing evaporation losses; b) reducing non-beneficial transpiration losses from weeds; and c) reducing non-beneficial drainage losses. In principle, the magnitude all three of these water saving techniques can be quantitatively estimated. A possible way to make these estimations is to apply standardized TE coefficients to the yield of various crops and varieties to determine what amount of the total water applied is consumed by transpiration. Then one could estimate how much of the drainage water is beneficially used. The balance would approximate the potential water savings from E and non-beneficial drainage.

Our opinion is that in the highly developed agricultural areas of the world, with the exception of many flooded rice systems, the opportunities for substantial water savings by any of these techniques are rather small. Also, it should be noted that these are “once and for all” water savings, which cannot increase indefinitely, and they can be very expensive. On the other hand, in areas of marginal agriculture, such as most of sub-Saharan Africa and the rainfed areas of many other regions, where the need is perhaps greatest, there is large potential for such improvements.

Last, to return to the question posed at the beginning, for reasons outlined here, and given the qualifications and caveats, we conclude that under the most prevailing conditions of agriculture today, the hypothesis that increasing yields will simultaneously increase transpiration losses and therefore water scarcity is valid.
References


Appendix A. The Process of Transpiration

In this appendix we attempt to briefly outline the process of transpiration in plants, as we understand it, so that the reader can see and appraise the basis from which the hypotheses in the main body of the text are derived. In this effort we have relied heavily on the clear and authoritative publications works of T. R. Sinclair and his co-authors and we advise other lay persons interested in this fascinating field to do the same. Many other works referenced below, especially Howell (1990a) and Euler and Goss (2003) should be perused from this base. These references may compensate for an economist and an engineer trespassing on such a technical and specialized field. However, this section is written mainly for economists and engineers and other non-specialists in a way that we—and therefore, we hope they—can understand, without doing too much damage to the ear of the specialist.

Transpiration is driven by meteorological conditions, regulated by plant-soil characteristics, and constrained by available water.

The first step in understanding the process of transpiration is to regard it as part of the rather miraculous chemical manufacturing process of the leaf, the process of photosynthesis (see Sinclair and Gardner, pp. 66-69; Tanner and Sinclair, p. 13). The leaf, employing radiant energy from the sun, acquires hydrogen and oxygen by breaking down water (itself a difficult task) extracted from the soil. It acquires carbon from carbon dioxide in the atmosphere, which diffuses into the plant through small pore-like holes on the leaf, the stomata. The leaf then re-assembles these elements into a simple carbon molecule, hexose, the “photosynthate”, which is the basic building-block of the plant biomass.

Finally, the hexose needs to be converted to final product biomass in the plant. Through a careful analysis of the assimilatory pathways, Penning de Vries (1975b) estimated that from 1 g of hexose, either 0.83 g of carbohydrates, 0.40 g of protein (assuming a nitrate source of N), or 0.33 g of lipids could be produced. Therefore, in principle the conversion coefficient, b, for taking hexose to biomass could range from 0.33 to 0.83. Sinclair and de Wit (1975), examined seed production in 24 crop species and found a range for b from 0.42 in sesame to 0.75 in barley and rice. (Tanner and Sinclair, 1983, p. 13; the table for the 24 crop species is included in Sinclair and Gardner, 1998, p. 69).

The next step in understanding the process of transpiration is to see how the plant manages the very difficult problem of acquiring carbon dioxide by diffusion through the stomata at the cost of water loss by transpiration through the same process. This problem is exacerbated by the fact that the concentration of carbon dioxide in the atmosphere is quite low. For every CO2 molecule in the atmosphere there are 100 water vapor molecules. Photosynthesis must scavenge for a trace amount of CO2 without losing water. Animals have a much easier task with water use efficiency: There are seven, O2 molecules (14 O molecules) for every water vapor molecule in the atmosphere, so getting oxygen without losing water is 700 times easier than getting CO2 without losing water. (Bugbee, personal communication, cited in Seckler, 2002).

\[\text{fn: Transpiration,} \quad \text{Sinclair and Gardner (eds.) Chapters 5 and 7, and more technically in Tanner and Sinclair, 1983 (a work referred to by one authority as “the seminal paper” in the field of plant water relationships).}\]
To manage the problem of acquiring carbon dioxide at the least cost in terms of transpiration losses, the leaf has developed a highly elaborate control system that carefully opens and closes the stomata in response to the carbon dioxide demands of the rate of photosynthesis. If the carbon dioxide concentration in the inter-cellular spaces of the leaf is too low, the stomata open wider, if the concentration is sufficient to meet photosynthetic demand the opening of the stomata becomes smaller. If water supply becomes highly constrained, the stomata are completely closed and photosynthesis stops. Howell (1990a) discusses various tests of the “optimal stomatal control theory” of the relationship between assimilation of carbon dioxide and loss of water through transpiration in plants. It is found that while there are differences among plants, they perform very close to the optimum position. A remarkable recent discovery in this field is that the stomata do not all open and close at once, or in the same degree. Instead, “patches” of stomata on one part of the leaf behave in one way, while those on other parts behave in another way. This has led to the conjecture, now being tested, that leaves are practicing a form of “distributed computing” among the stomata, a form of computing which is at the frontier of computer science and which, if proven true, would be the first such process discovered in biology (Mott, 2003).

The third step in understanding transpiration is to recognize the three different kinds of plants, which have substantially different photosynthetic pathways and, hence transpiration efficiencies under the same atmospheric and other environmental conditions (see the discussion in Howell, 1990a, pp.395-396).

The C3 plants are the most common crop plants (wheat, barley, soybeans…..). Unfortunately, they are also the least efficient assimilators of carbon dioxide from the atmosphere. Therefore, they must keep their stomata open more than the other plants under the same atmospheric conditions and, hence, they have the lowest transpiration efficiency, TE (biomass per unit water transpired).

The C4 plants (maize, sorghum, sugar cane…) have developed an ingenious add-on to the basic C3 process. They have an enzyme that has twice the affinity for absorbing carbon dioxide as that in C3 plants. C3 plants also have photorespiration which occurs with photosynthesis in light and requires oxygen. This process does not occur in C4 plants. Consequently, C4 plants have 2-3 times higher TE than C3 plants.

The CAM plants (pineapple, agave …) have the ability to assimilate CO$_2$ during the night and store it in the form of organic acids. During the day the stored CO$_2$ is available for producing carbohydrates by photosynthesis. This enables CAM plants to close their stomata during the daytime, when transpiration is highest, and open the stomata at night when it is lowest. CAM plants can attain a TE as much as 10 times that of C3 plants; however, their biomass production per unit land area is low.

Last, there are facultative plants, of which the ornamental Jade plant is one example, that can switch between the CAM and C3 processes depending on water availability (Bruce Bugbee, personal communication). Why, one may ask, if they can do CAM, would they want to do C3? The reason is that the C3 process is more energy efficient. Pineapples also seem to have this facility to some degree. Under irrigated conditions pineapples open their stomata in the daytime, but when it is dry they open them only at night (Sinclair and Bennett, 1998).

In sum, the TE of plants is determined first and foremost by meteorological conditions (saturation vapor pressure deficit). But given these conditions, TE also varies greatly among the
three major groups of plants—C3, C4, and CAM—and, within these groups, TE varies according to the crop products: carbohydrates, proteins, and lipids. All of these variations and complications are governed by the strict relations of chemical manufacturing processes combined with the elaborate control functions of the stomata. When water is limiting, the TE of biomass production is not necessarily affected, but the TE of marketable yield can vary significantly depending on the water availability at various crop stages.
Appendix B. Detailed Maize Yield-ET Analysis

Yield-ET data from multiple locations combined into a single plot may initially appear to indicate there is little correlation between yield and ET. We contend, however, that this apparent lack of correlation is due primarily to two factors: 1) the data come from several different locations with different saturation vapor pressure deficits; and 2) the E part of ET is what introduces most of the variability in the yield-ET relationship once the data have been normalized for \( \Delta e \). To demonstrate these assertions we conducted the following analysis and arrived at an important and interesting conclusion—CWP is maximized by full irrigation of a smaller area rather than by deficit irrigation of a larger area with the same volume of water.

In an interesting study, Zwart and Bastiaanssen (2004) conducted an extensive literature review to develop a database of wheat, rice, and maize grain yields, and cotton seed and lint yields, versus actual ET (ET\(_a\)). For inclusion in the database ET\(_a\) had to be measured and the method of measurement reported. Figure B1 shows maize grain yields against ET\(_a\), digitized from Figure 2d of Zwart and Bastiaanssen (2004).

Figure B2 is derived from Figure B1 by converting the grain yield to dry matter yield according to \( Y_{dm} = 2.04 Y_{gr} + 2.47 \). The points in Figure B2 were filtered to only include data between the 5 and 95 percentiles of the entire CWP range\(^\text{19}\) in the Zwart and Bastiaanssen (2004) database. The \( Y_{P dm} \) curve was derived as the envelope of maximum \( Y_{dm} \) values.

The intercept of the \( Y_{P dm} \) curve on the ET-axis in Figure B2 represents what we call the basal evaporation (E\(_b\)). For this maize data set E\(_b\) is 87 mm. To estimate the actual E and T associated with each \( Y_{dm} \) the TE associated with each data point must first be determine. If the seasonal average \( \Delta e \) for each point was known the Bierhuizen-Slatyer (1965) equation (Eq. 2 in the text) could be used. But since \( \Delta e \) was not available\(^\text{20}\) we estimated TE for each data point as the average slope of two lines: one line, representing the minimum TE, being that passing through E\(_b\) on the ET-axis and the data point; and the other line, representing the probable maximum TE, being that passing through E\(_b\) on the ET-axis and \( Y_{P dm} \) at ET\(_a\) for the data point. Once the TE is determined T is estimated as \( Y_{dm} \) divided by TE and E is ET\(_a\) minus T. The summary results for this maize data set are presented in Table B1 and appear reasonable. The \( \Delta e \) values summarized in Table B1 were estimated assuming a k factor of 9.1 Pa for maize in Eq. 2.

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\(^{19}\) The entire CWP-range in the Zwart and Bastiaanssen (2004) database for maize is 0.2 to 4.0 kg m\(^{-3}\). The 5 to 95 percentile range is 1.1 to 2.7 kg m\(^{-3}\).

\(^{20}\) Zwart and Bastiaanssen (2004) recognized and discussed the inverse relationship of \( \Delta e \) on CWP. Since \( \Delta e \) generally decreases with distance from the equator, Zwart and Bastiaanssen plotted the maximum CWP against latitude for each location and crop in their database. They found that between 30\(^\circ\) and 40\(^\circ\) of latitude tended to be most favorable for maximizing CWP in grain production and concluded this was likely related to \( \Delta e \). We encourage Zwart and Bastiaanssen to include the associated mean growing season \( \Delta e \) when possible in their database.
Figure B1. Maize grain yield versus actual ET digitized from Zwart and Bastiaanssen (2004).

Figure B2. Maize dry matter yield versus actual ET, derived from Figure B1. Dry matter yield estimated from grain yield by $Y_{dm} = 2.04 Y_{gr} + 2.47$. Data filtered to only include points between the 5 and 95 percentiles of the entire CWP range.
Table B1. Maize yield-ET summary results from estimated TE in Figure B2. ET<sub>a</sub> and Y<sub>gr</sub> digitized from Zwart and Bastiaanssen (2004) and filtered for CWP between 1.1 and 2.7 kg m<sup>-3</sup>. Y<sub>dm</sub>, TE, Δe, T, and E are calculated estimates.

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*With the exception of the average, T and E cannot be summed to get ET<sub>a</sub> because the summary T and E values are not necessarily for the same data points, i.e. the point with minimum T may not be the point with minimum E.

Figure B3 shows the maize grain yield versus T and ET normalized for the estimated saturation vapor pressure deficit using a reference Δe of 1 kPa. The amount of normalized evaporation is represented by the distance from the T<sup>′</sup> line to the ET<sup>′</sup> points for a specific yield. Figure B3 demonstrates that when normalized for Δe the yield and ET are strongly correlated and the variability is due to E. It should be noted, however, that this analysis out of necessity is idealized and that in reality there would be some variability in the yield-T relationship. But we doubt this variability would be significant or alter our conclusion that the Δe-normalized yield-T relationship is essentially linear and that E is the source of variability in the yield-ET relationship.

Figure B3. Maize grain yield versus T+E normalized for the estimated saturation vapor pressure deficit using a reference Δe of 1 kPa. Derived from Figure B1.
It is interesting and important to note from Figure B3 that E, which is the non-productive part of ET, decreases with increasing T particularly as a fraction of ET. This is likely due to the greater effective ground cover of crops having greater T. Thus, from the standpoint of maximizing CWP, evaporation should be minimized by maximizing T, which implies intensification of farming. Thus, in the debate of whether to spread a limited water supply over a larger area and deficit irrigate or to fully irrigate a smaller area, we conclude from this exercise that CWP is maximized by irrigating the smaller area.
Model for Estimating Evaporation and Transpiration from Row Crops

MODEL FOR ESTIMATING EVAPORATION AND TRANSPERSION FROM
ROW CROPS

By Francesca Ventura,¹ Ben A. Faber,² Khaled M. Ball,³ Richard L. Snyder,⁴
Donatella Spano,⁵ Pierpaolo Duce,⁵ and Kurt F. Schulbach¹

ABSTRACT: Accurate estimates of crop evapotranspiration ETc that quantify the total water used by a crop,
are needed to optimize irrigation scheduling for horticultural crops and to minimize water degradation. During
early growth, accurate assessments of ETc are difficult in vegetable crops because of high soil evaporation
due to frequent irrigation. A model to estimate ETc for vegetable crops, using only daily reference evapotranspiration
data as an input parameter, was developed. It calculates crop transpiration and soil evaporation based on ground
cover and daily radiation intercepted by the canopy. The model uses a two-stage soil evaporation method adapted
to conditions of variable reference evapotranspiration. The model was evaluated against data using measurements
from two seasons of lettuce crop, two tomato fields in the same season, and one season of broccoli crop
production. Using all of the crop data, the root-mean-square error for measured versus modeled daily ETc
was 0.72 mm day⁻¹, indicating that the model works well.

INTRODUCTION

Horticultural crops are widely cultivated in regions with a Mediterranean climate, where irrigation is available. The
annual growth habit and shallow rooting of many of these crops (i.e., vegetables) often requires frequent irrigation, which
may lead to excessive water use, low irrigation efficiency, and groundwater contamination from nitrate and pesticide
leaching. Accurate estimates of crop evapotranspiration ETc are important to optimize irrigation scheduling, enhance efficiency,
and prevent groundwater pollution.

When row crops are in an early stage, ETc is dominated by soil evaporation rate. Later, the plant cover increases and the
evapotranspiration rate is dominated by transpiration from the plants. Commonly, ETc is estimated by multiplying a reference
evapotranspiration ET₀, calculated from meteorological data, by a crop coefficient Kc, which accounts for crop factors and
management. Crop coefficient Kc values account for irrigation and rainfall frequency; however, because of the difficulty in
estimating soil evaporation, an average Kc value is often used during early growth of row crops to account for wetting
frequency. Several models able to separately estimate evapotranspiration from the soil E and crop transpiration T are available in
the literature. Most of them are analytical models (Van Bavel et al. 1984; Shuttleworth and Wallace 1985) and require many
crop and soil parameters that are not commonly available.

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Note: Discussion open until May 1, 2002. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript was submitted for review and possible publication on February 29, 2000; revised February 8, 2001. This paper is part of the Journal of Irrigation and Drainage Engineering. Vol. 127, No. 6, November/December, 2001. ASCE. ISSN 0733-9634/01/$05.00 © 2001. Paper No. 22174.

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E and T model for lettuces (Gallardo et al. 1996) was previously developed, but the lettuce canopy is unique relative to
other horticultural crops. In this paper, a model that is similar to the Gallardo et al. (1996) model, but improved to account for
irrigation method and different canopies, is presented. The advantage of this model is that the only daily input parameter
required is ET₀.

MODEL DESCRIPTION

The model separates ETc into E and T by assuming the ratio of the maximum T to ET₀ rate is the same as the fraction of
total daily solar radiation intercepted by the canopy. The solar radiation that is not intercepted by foliage contributes to soil
evaporation, but the E rate also depends on soil wetness and hydraulic properties. It is assumed that convective energy con-
tributes to E and T in a similar proportion as radiation. This is a fair assumption because the percentages of canopy ground
cover and light interception are similar. In the model, T is related to the percentage of solar radiation that is intercepted
by the crop canopy R, which is estimated as a function of the percentage of ground covered by the canopy. The percentage
ground cover on each day C is estimated as a function of cumulative ET₀.

Soil evaporation is a two-stage process (Lemon 1956; Itoo et al. 1974). During stage 1 the evaporation rate depends only
on the energy available to vaporize water. Eventually, the soil dries to stage 2 and the evaporation rate is limited by soil
hydraulic properties. The soil evaporation rate depends on the fraction of the exposed soil that is wetted by irrigation and the
percentage of light reaching the wet surface. This depends on the irrigation method and the location of wetted surface rela-
tive to the canopy. Soil that is not wet or exposed to sunlight is assumed to have zero evaporation. Evaporation is separated
into stages 1 and 2 only for wet, exposed soil.

Modeling of Canopy Development

The ground cover percentage on the nth day Cn is used to estimate radiation interception by the plants. A sigmoidal func-
tion was used to estimate crop ground cover development during the season (Charles-Edward et al. 1986), with normalized
cumulative ET₀. Nn as the input parameter. Substitution of N for degree-days gives good results because there is a high cor-
relation between N and normalized degree-days, i.e., heat units. Normalized cumulative N is calculated as

\[ N_n = \sum_{i=1}^{n} \frac{ET_0}{ET_0} \]  \hspace{1cm} (1)
where \( j \) = number of days after planting date; and \( ET_{aw} \) = cumulative \( ET_i \) at the end of the season. Ground cover \( C_i \) values are determined from seeding or transplanting until the maximum ground cover is reached. For lettuce and broccoli, this occurs at or near the end of the season. For tomatoes, the maximum ground cover occurs during midseason. The percentage ground cover is normalized as \( P_i = C_i / C_o \), where \( C_i \) is the observed ground cover on the \( i \)th day and \( C_o \) is the maximum ground cover percentage for the season. In the model, \( P_i \) is estimated as a sigmoidal function of \( N \) and the percentage ground cover on the first day of the season \( P_1 \).

\[
P_i = P_1 + \frac{1 - P_1}{1 + e^{-N/P_{20}}}
\]

After determining \( P_o \), ground cover percentage is calculated as \( C_o = P_o C_o \).

**Radiation Interception and Transpiration**

Percentage radiation interception by the canopy on the \( j \)th day is calculated as \( R_j = 0.63 + 1.37C_j - 0.0035C_j^2 \). The fraction of solar radiation intercepted by the canopy on the \( j \)th day is \( R_j/100 \), and the fraction of radiation intercepted by the soil is \( (1 - R_j/100) \).

Transpiration from the crop is estimated as the product of the maximum possible \( ET_i \) on the \( j \)th day and the fraction of radiation intercepted by the canopy.

\[
T_i = ET_{aw} \left( \frac{R_j}{100} \right)
\]

where \( ET_{aw} \) is estimated as the product of \( ET_{aw} \) and the maximum possible \( ET_i \) on the \( j \)th day. The maximum \( K_0 \) is the stage 1 soil evaporation to or the maximum crop evapotranspiration, whichever is higher on the \( j \)th day of the season.

**Soil Evaporation without Crop**

Soil evaporation is modeled as a two-stage process, where stage 1 is limited by energy availability and stage 2 is limited by soil wetness and hydraulic properties (Ritchie 1972; Boes- ten and Strooosnijder 1986; Strooosnijder 1987; Ritchie and Johnson 1990; Burman and Pochop 1994; Gallardo et al. 1996). During stage 1, the soil is sufficiently wet for the water to be transported to the surface at a rate equal to \( ET_{aw} \) for bare soil. Therefore the stage 1, bare soil evaporation on the \( j \)th day after irrigation \( E_{i1} \) is limited only by the supply of energy for vaporization and

\[
E_{i1} = ET_{aw} K_0
\]

The wet soil crop coefficient \( K \) is estimated using the initial growth period 2-day wetting frequency \( K \) versus \( ET \), curve presented by Doorenbos and Pruitt (1977). A linear regression of \( K \) versus \( ET \), using that data gave

\[
K_j = 1.05 - 0.03ET_j
\]

Starting immediately after irrigation, a plot of cumulative soil evaporation \( CE_i \), or cumulative maximum soil evaporation \( CE_{aw} \), whichever is smaller, versus the square root of the cumulative stage 1 evaporation \( \sqrt{CE_{i1}} \), is used to determine the soil hydraulic factor \( \beta \), which is used to estimate soil evaporation during stage 2 evaporation. While in stage 1, the data points lie along the \( y = x \) curve, and they diverge and follow a linear trend as soon as the soil reaches stage 2 evaporation. The \( \sqrt{CE_{1}} \) value where the evaporation changes from stage 1 to stage 2 is the hydraulic factor \( \beta \). The slope of the linear, stage 2 portion of the \( CE_i \) curve is also equal to \( \beta \). The hydraulic factor of \( \beta \), is found by eliminating the data pairs that fall in stage 1 evaporation and calculating a linear regression through the remaining data. Data pairs are eliminated until the minimum \( \sqrt{CE_{1}} \) is greater than the slope of the linear regression through the origin of all remaining data pairs.

Once experimentally determined for a field, \( \beta \) is used to calculate the onset of stage 2 evaporation and \( CE_t \), during stage 2. For all values of \( \sqrt{CE_{1}} > \beta \), stage 2 soil evaporation rate for the \( j \)th hour is calculated as \( E_{i2} = \frac{ET_i}{100} \).

\[
E_{i2} = \beta \left( \frac{\sum_{j=1}^{j} E_{i1}}{\beta} \right)^{1/2} - \beta \left( \frac{\sum_{j=1}^{j} E_{i1}}{\beta} \right)^{1/2}
\]

Following a new irrigation or a rainfall the evaporation rate returns to stage 1. Note that the soil evaporation model described above will underestimate \( CE_i \), slightly at low \( ET \), rates and the error can increase to as much as 10% at the end of stage 1 when the \( ET_i \) rates are high, i.e. \( ET_i > 8.0 \, \text{mm day}^{-1} \). The error is small when used for separating \( ET_i \) into \( E \) and \( T \).

**Soil Evaporation with Crop**

**Sprinkler Irrigation or Rainfall**

When a crop is present over a soil that is completely wetted by sprinkler irrigation or rainfall, then the soil evaporation \( E \), is estimated by adjusting \( E \), for the percentage of solar radiation reaching the wetted surface \( (100 - R) \).

\[
E_r = E \left(1 - \frac{R}{100}\right)
\]

Only the fraction of solar radiation that is not intercepted by the canopy is assumed to reach the surface, and only the fraction of the soil surface receiving the solar radiation that is wet is assumed to contribute to soil evaporation. The shaded soil surface area between the furrow middles shown in Fig. 1 approximately represents the area that would contribute to soil evaporation if wet.

**Trickle (Drip) Irrigation**

Generally, when surface drip systems are used to irrigate field and row crops, there is one drip line per bed. However, there can be one or two rows of plants in each bed depending on the crop. In both cases, assume that the beds comprise 50% of the total surface area and that the drip line lies in the middle of the bed.

"FIG. 1. Canopy Effect on Soil Evaporation from Sprinkler-Irrigated Row Crops or Crops Receiving Rainfall: Wetted Soil Surface That Receives Radiation Is Shadowed."
FIG. 2. Canopy Effect on Soil Evaporation from Drip-Irrigated Row Crops: (Left) Entire Wetted Surface Receives Sunlight; (Right) Canopy Reduces Sunlight Penetration to Wetted Surface

\[
E_i = E_o \left( \frac{W}{100} \right) \text{ if } R_i \leq B - W
\]

\[
E_i = E_o \left( \frac{B - R_i/2}{100} \right) \text{ if } R_i > B - W
\]

100% \[ \begin{align*}
E_o & = E_o \left( \frac{W}{100} \right) \\
E_i & = E_o \left( \frac{100 - R_i}{100} \right)
\end{align*} \]

FIG. 3. Canopy Effect on Soil Evaporation from Furrow-Irrigated Row Crops: (Left) Entire Wetted Surface Receives Sunlight; (Right) Canopy Reduces Sunlight from Reaching Wetted Furrows

When there are two rows of plants per bed and they are planted at 1/3 and 2/3 of the bed width, then the wetted surface area is exposed until the canopy grows sufficiently to cover the wet surface. This is illustrated in Fig. 2. If \( W \) is the percentage of total area that is wetted, \( R_i \) is the percentage of light interception by the canopy, and \( R_i/2 \leq B/2 - W \), then the soil evaporation is

\[
E_i = E_o \left( \frac{W}{100} \right) \text{ if } R_i \leq B - W
\]

\[
E_i = E_o \left( \frac{B/2 - R_i/2}{100} \right) \text{ if } R_i > B - W
\]

However, when \( R_i > W \), then \( E_i = 0 \). In this paper, only the case with one row of plants per bed was investigated.

Furrow Irrigation

For furrow irrigation, again it is necessary to estimate the exposed, wetted soil surface area. The percentage wetted area \( W \) is first determined from the midpoint of one furrow to the next (Fig. 3). For example, if the area in the wetted perimeter of the irrigated furrows is 40% of the total area, then \( W = 40\% \). If every second furrow is irrigated and the area in the wetted perimeter is 20%, then \( W = 20\% \). The wetted surface is not considered shaded until the light interception exceeds the percentage area for the planting bed \( B \). Therefore, if \( R_i < B \), then

\[
E_i = E_o \left( \frac{W}{100} \right)
\]

When \( R_i > B \), then

\[
E_i = E_o \left( \frac{100 - R_i}{100} \right)
\]
Crop Evapotranspiration

After determining the transpiration and soil evaporation rates, crop evapotranspiration on the i-th day is calculated as

\[ ET_i = E_i + T_i \]  

(14)

**MATERIAL AND METHODS**

**Crop Growth**

The \( a \) and \( b \) empirical parameters in (2) were determined with ground cover measurements using a photographic technique. Data were collected during the growth of 21 vegetable crops (Tables 1–3) that were planted at different times of the year in three locations in California (Salinas Valley, the Oxnard Plain, and the Imperial Valley). Climatically, the sites are located along the foggy central coast, the mixed foggy and sunny south coast, and in a below sea level desert (during winter). The camera was fixed on top of a 3.0-m-long pole, taking care to keep it perpendicular to the vegetation surface. Photographs were taken every 7–10 days and were scanned and image processed to estimate the percentage of area covered by the crop canopy. These data, together with the daily \( ET_0 \) collected from nearby California irrigation management information system stations (Snyder and Fruitt 1992), were used to estimate the \( a \) and \( b \) coefficients in (2).

**Soil Evaporation**

Actual evapotranspiration \( ET \), experimental data were obtained by measuring the energy balance over several crops and calculating the latent heat flux density \( LE = ET_0 \), which equals \( ET_0 \)

\[ LE = R_{net} - G - H \]  

(15)

Net radiation \( R_{net} \) and soil heat flux \( G \) were measured respectively a net radiometer (model Q-7.1, REBS Inc.) 1.5 m above the soil and soil heat flux plate (model HFT3, REBS Inc.), sensible heat flux \( H \) was measured directly with the eddy covariance method (Monteith and Unsworth 1990; Brussel 1984). Eddy covariance requires simultaneous measurements of the fluctuating components of wind and temperature in the constant flux region over the surface. The instantaneous turbulent flux of both these quantities has generally a vertical component; if there is not a net transport of heat toward or away from the surface the fluctuations of the two quantities are correlated. Measuring both the temperature and wind fluctuations, with a 1D sonic anemometer (model CA27, Campbell Scientific Inc.) and computing the correlation over a suitable time period provides a measure of \( H \) to use in (15) to determine \( LE = ET_0 \). When sonic anemometer data were unavailable, \( H \) was estimated using the surface renewal method (Paw U et al. 1992; Snyder et al. 1996; Spano et al. 1997). Half-hourly soil evaporation data were measured where model validation was performed to determine the \( b \) parameters. In each case, data were collected as the soil dried after a heavy irrigation.

**Estimating Soil Hydraulic Factor \( b \)**

In experiments to determine \( b \), the soil evaporation was measured each half-hour, so the subscript \( j \) represents the j-th half-hour sample. The square root of the cumulative stage 1 evaporation, through the j-th half-hour is \( b = \sqrt{CE_j} \), where the initial value for \( k = 1 \). The slope of \( CE_j \) versus \( \sqrt{CE_j} \) is calculated first for \( j = m \) to \( n \), where \( m \) gives a value for \( \sqrt{CE_j} \), that is slightly less than the value of the point where the plot of \( CE_j \) versus \( \sqrt{CE_j} \) separates from the curve of \( CE_j \) versus \( \sqrt{CE_j} \), and becomes linear, and \( n \) is the total number of half-hour samples. This is illustrated in Fig. 4 where the dotted line is the linear regression of all data pairs with the x value \( \sqrt{CE_j} \). Clearly, this does not represent where the measured data separate from the curve of \( CE_j \), and becomes linear. A second minimum x value was selected as \( \sqrt{CE_j} \) = 4.00 and a new linear regression was calculated (solid line in Fig. 4). The minimum x value is still to the left of the curve \( CE_j \), line, so a higher minimum value is still needed. Note that the slope increased slightly as a higher value for the minimum x value was used, but the difference between the slope and minimum x value decreased. To find \( b \), the minimum x value is increased until it is bigger than the slope of the regression. In this example, the dashed line with the minimum x value of 4.05 has a slope of 4.02, so a \( b = 4.02 \text{ mm} / \text{d} \) is selected for this soil.
Estimating Soil Evaporation Using $\beta$ and Daily Data

The same soil evaporation relationships apply for daily as well as for hourly or half-hourly data. Eq. (5) is used to estimate soil evaporation when the square root of the cumulative daily stage 1 evaporation is $<\beta$, i.e., $\sqrt{CE}$ is $<\beta$ on the ith day after irrigation. When the square root of the cumulative stage 1 soil evaporation is $>\beta$ (i.e., $\sqrt{CE} > \beta$ on the ith day after irrigation), then (16) is used

$$E_2 = \beta \left( \sum_{i=1}^{n} E_i \right)^{1/2} - \beta \left( \sum_{i=n+1}^{n+m} E_i \right)^{1/2}$$

(16)

where the subscript $j$ = number of days after irrigation.

Model Validation

The model was evaluated making comparison with actual evapotranspiration $ET_a$ data measured on three different crops: lettuce (*Lactuca sativa*) during 2 years in the same plot; tomato (*Solanum esculentum*) in two locations during the same year; and broccoli (*Brassica oleracea*). The growing conditions at each site are summarized in Table 4. The $ET_a$ data in five experiments were determined using the energy balance and eddy covariance methods as described earlier. Evapotranspiration was measured hourly and summed to obtain daily values.

Lettuce

Lettuce $ET_a$ data were measured at the University of California experimental farm in Imperial Valley, Calif. (32°50'N, 115°30'W), which is the desert below sea level in an irrigated area. Crop evapotranspiration was measured both years on the same plot ($60 \times 60$ m) with a fetch of 37 m. Not all the data obtained were considered to be reliable due to the meteorological condition, and 13 days of $ET_a$ on the first year, and 39 on the second, were used for the model validation.

**Tomato**

The first experiment on tomatoes was carried out in a commercial farm in Ventura, Calif. (33°30'N, 119°20'W). This area is characterized by a humid and foggy climate in summer, with clear skies only during the central part of the day. The $ET_a$ was measured using eddy covariance and energy balance with a fetch of 160 m.

The second tomato experiment was conducted in a commercial field in Oristano, Italy (39°50'N, 8°35'E), in an area that is characterized by a warm, humid climate. Measurements were taken on a 50 x 200 m plot with 45-m fetch. The $ET_a$ data were estimated using the Penman-Monteith equation (Allen et al. 1994) and weather data from the University of Sassari experimental farm, which is located 4 km from the field.

**Broccoli**

The $ET_a$ measurements on broccoli were collected near Ventura, Calif., on the same farm where the tomato data were taken, in a 200 x 200 m plot with 100-m fetch.

**RESULTS**

Ground cover data from 21 crops grown in all seasons over several years were collected and divided into groups according to planting period. In addition, transplanted crops were separated from sowed crops. Differences in growth among crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Harvest date</th>
<th>Irrigation date</th>
<th>Irrigation system</th>
<th>Measurement dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Chirishad&quot; lettuce</td>
<td>11/20/95</td>
<td>3/27/96</td>
<td>10</td>
<td>Sprinkler (3); furrow (7); B = 60% From 12/1/95 to 2/28/96</td>
</tr>
<tr>
<td>&quot;Winterhaven&quot; lettuce</td>
<td>9/17/96</td>
<td>2/5/97</td>
<td>14</td>
<td>Sprinkler (8); furrow (6); B = 60% From 10/25/96 to 2/4/97</td>
</tr>
<tr>
<td>&quot;3153&quot; tomato</td>
<td>4/4/96</td>
<td>8/15/96</td>
<td>6</td>
<td>Furrow; B = 60%            From 4/4/96 to 6/15/96</td>
</tr>
<tr>
<td>&quot;Rossa&quot; tomato</td>
<td>5/16/97</td>
<td>8/25/97</td>
<td>14</td>
<td>Sprinkler (3); drip (11); W = 30% From 5/16/97 to 2/15/97; Second: From 7/1/97 to 7/13/97</td>
</tr>
<tr>
<td>&quot;Green Belt&quot; broccoli</td>
<td>12/19/95</td>
<td>4/15/96</td>
<td>2 (-7 rain)</td>
<td>Sprinkler                 From 4/5/96 to 4/5/96</td>
</tr>
</tbody>
</table>

Note: Th. = thinning date; B = bed area percentage.

**Table 4. Crop and Irrigation Characteristics for Sites Used to Estimate $ET_a$.**

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were not evident, but the crop development varied depending on the growing season. Transplanted crops had a slower initial growth rate than sown crops.

Percentage of ground cover during the various seasons were calculated using (2) and the results were compared to measured values. The model simulated the crop development with a root-mean-square error (RMSE) within 11% of the estimated ground cover, as shown in Tables 1–3. The a and b coefficients are given in the footnotes of Tables 1–3.

The \( \beta \) factor was determined for each experimental site where \( ET_c \) was measured using one dry-down cycle. It would be useful to establish a functional relationship between the \( \beta \) factor and one or more soil hydraulic characteristics that are easier to evaluate, but unfortunately \( \beta \) was unrelated to soil texture (Table 5) and infiltration rate (Boersen and Stroosnijder 1986, Snyder et al. 2000). More research is needed to determine which soil physical factors affect the \( \beta \) parameter; at this time it seems that a micrometeorological method to estimate soil evaporation during a dry-down cycle provides the best procedure to determine \( \beta \).

The \( E \) and \( T \) model was evaluated against \( ET_c \), data using measurements from five plots including crops of lettuce, tomato, and broccoli (Figs. 5–7). The figures show the modeled \( ET_c \) during the growing season, measured \( ET_c \) values, and irrigation and rainfall events (I&R) in the lower part and the two modeled \( ET_c \) components, \( E \) and \( T \), in the upper part. In all cases, the \( E \) contribution to \( ET_c \) was considerable at the beginning of the season and became progressively less important, or approached zero, with the crop growth. Fig. 6 shows that soil evaporation from the 1997 tomato crop approached zero very early in the season when the percentage of soil wetted by the drip irrigation became smaller than the soil covered by the canopy. With the other crops \( E \) contributed to \( ET_c \) whenever irrigation was applied. Experimental data were taken during low \( T \) periods—when the beginning of the season, and during low \( E \) periods—when the end of the season, and the model seems to fit both situations well. The RMSE values for measured versus modeled \( ET_c \) were 0.63 mm day\(^{-1}\) for lettuce, 0.55 mm day\(^{-1}\) for tomato, and 0.54 mm day\(^{-1}\) for broccoli.

Measured \( ET_c \) data in all five experiments versus the corresponding model estimates are plotted in Fig. 8. The overall

### TABLE 5. Hydraulic \( \beta \) Factor and Soil Characteristic for Experimental Sites

<table>
<thead>
<tr>
<th>Experimental site</th>
<th>( \beta ) (mm day(^{-1}))</th>
<th>Soil type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperial Valley, Calif.</td>
<td>4.3</td>
<td>Very fine sandy loam</td>
</tr>
<tr>
<td>Ventura, Calif.</td>
<td>3.8</td>
<td>Sandy loam</td>
</tr>
<tr>
<td>Orsano, Italy</td>
<td>1.9</td>
<td>Clayey sandy loam</td>
</tr>
</tbody>
</table>

### FIG. 5. Modeled Crop Evapotranspiration \( ET_c \), Transpiration \( T \), Evaporation \( E \), Irrigation and Rainfall Events (I&R), and Measured Actual Crop Evapotranspiration \( ET_c \), for 1995–1996 Lettuce Crop

![Graph showing modeled vs measured ETc for 1995-1996 Lettuce Crop](image)

### FIG. 6. Modeled Crop Evapotranspiration \( ET_c \), Transpiration \( T \), Evaporation \( E \), Irrigation and Rainfall Events (I&R), and Measured Actual Crop Evapotranspiration \( ET_c \), for 1997 Tomato Crop

![Graph showing modeled vs measured ETc for 1997 Tomato Crop](image)

### FIG. 7. Modeled Crop Evapotranspiration \( ET_c \), Transpiration \( T \), Evaporation \( E \), Irrigation and Rainfall Events (I&R), and Measured Actual Crop Evapotranspiration \( ET_c \), for 1996 Broccoli Crop

![Graph showing modeled vs measured ETc for 1996 Broccoli Crop](image)

### FIG. 8. Observed Crop Evapotranspiration \( ET_c \) versus Modeled Crop Evapotranspiration \( ET_c \), Using Data from All Five Field Experiments

![Graph showing observed vs modeled ETc](image)

RMSE is equal to 0.72 mm day\(^{-1}\) with less accurate results during periods with low \( ET_c \). All of the data with \( ET_c < 3 \) mm day\(^{-1}\) occurred in the winter time lettuce experiment. Comparing daily evapotranspiration data calculated with the Food and Agricultural Organization of the United States (FAO) \( K_c \) model (Doorenbos and Pruitt 1977) with the measured \( ET_c \), shows a greater data scattering (\( R^2 = 0.61 \)) and RMSE = 0.90 mm day\(^{-1}\).

### CONCLUSIONS

An evapotranspiration model for vegetable crops is reported. The model estimates evaporation from bare soil and
transpiration from the vegetation. Model results show good agreement with ETc measurements taken on three different crops in five experiments. The model uses daily ETc as the single input parameter. This makes it suitable for use by farmers, optimizing irrigation schedules for horticultural crops. This could potentially lead to more efficient water usage and reduced groundwater contamination.

ACKNOWLEDGMENTS

The writers would like to acknowledge the assistance of Susan Mills from Ventura, Calif., and Marcello Onorato from Oristano, Italy.

REFERENCES


NOTATION

The following symbols are used in this paper:

- a, b: regression parameters;
- Cg: ground cover percentage on 1st day (%);
- Cm: maximum ground cover percentage (%);
- CE: cumulative bare soil evaporation (mm);
- Ee, Ee1, Ee2: soil evaporation, from bare soil, general, in stage one, and in stage two (mm);
- ETa: actual evapotranspiration (mm);
- ETc: crop evapotranspiration (mm);
- ETp: maximum possible ETc, (mm);
- ETa: reference evapotranspiration (mm);
- ETaE: cumulative ETa at end of season (mm);
- G: soil heat flux density (W m⁻²);
- H: sensible heat flux density (W m⁻²);
- Kc: crop coefficient;
- Ks: wet soil crop coefficient;
- N: normalized cumulative reference evaportranspiration;
- R: percentage radiation interception by canopy on 1st day (%);
- Rb: net radiation (W m⁻²);
- T: transpiration (mm);
- W: percentage irrigation water area (%); and
- β: soil hydraulic factor (mm).
The Promise of Regulated Deficit Irrigation in California’s Orchards and Vineyards

By David Goldhamer and Elias Fereres, UC Davis, IAS-CSIC and University of Cordoba, Spain
The Promise of Regulated Deficit Irrigation in California’s Orchards and Vineyards

By David A. Goldhamer, Water Management Specialist, University of California, and Elias Fereres, Professor, IAS-CSIC and University of Cordoba, Spain

Agriculture uses about 75 percent of all the developed water in California, and the expanding population and efforts to maintain or improve animal habitat and stream flows will require even more water in the future. With no significant expansion of water supplies and possible partial loss of existing resources, agricultural water use is being seen by many as a potential water source. The recent controversy over the transfer of water from agriculture in Imperial County to the City of San Diego illustrates this issue. Some maintain that Imperial growers could free up the amount of water in question by improving their surface irrigation management, such as waste less water by reducing deep percolation below the crop root zone or end of field runoff. The growers argue that there are limits to how much water can be saved by reducing irrigation water losses (also called improving application efficiency) and point to reduced planting acreage, increased salinity, and associated loss of production and agricultural jobs as likely effects.

Statewide, California growers have steadily improved their application efficiency over the last couple decades. Moreover, deep percolation and runoff are usually only temporary losses on a small scale (the field being irrigated). Although quality may be degraded by fertilizers and other agricultural chemicals, water lost to deep percolation eventually moves into the water tables where it can be pumped and reused (see Figure 1). An exception to this is when it enters a salty, perched water table, usually making it unusable, or when it flows to the ocean. Runoff is often collected and reused on another field on the farm. Recognizing this and the fact that most California growers have become highly efficient in their irrigation management shows that there is limited opportunity to free up net water by improving application efficiency. Additionally, the use of California Irrigation Management Information System (see “Quantitative Irrigation Scheduling Does Work”) data has allowed growers not to over-irrigate crops, minimizing the loss of water to deep percolation.

Generally a near-linear relationship exists between ET and crop production because transpiration, the movement of water vapor from the interior of the leaf to the surrounding atmosphere and the uptake of carbon dioxide, the basic building block required in the process of photosynthesis, both use the same plumbing at the leaf surface—the stomata. These are very small openings usually located on the undersides of leaves that regulate the movement of both water vapor and carbon dioxide. Indeed, it’s often said that the plant trades water for carbon and if the goal is to maximize carbon uptake to achieve high yields, potential transpiration must be met. Thus, limiting transpiration (water stress) has usually been associated with production losses and lower grower profit.
While this is true for most field and row crops, it’s not necessarily true for trees and vines. Lack of water (water stress) reduces the vegetative growth of plants but doesn’t necessarily result in reduced fruit yield in trees and vines as it does with most field and row crops (cotton being an exception). Thus it is possible to reduce transpiration of trees and vines without reducing yield.

We have conducted RDI research on the major tree crops in California—pistachio, olive, prune, and citrus—and identified numerous species where significant amounts of water can be saved without having a negative impact on production or grower profit. We found that while the relationship between gross fruit yield (mean of three years) and applied water was fairly linear (see Figure 2a) relationship between gross revenue ($/acre) and applied water was completely different (see Figure 2b). Many of the RDI regimes had higher gross revenue than the full irrigation control while applying from 4 to 8 inches less water. This was due to significantly lower creasing (higher fruit quality), especially with early season stress. This illustrates a major difference between row/field crops and tree/vine crops.

Almond trees present the best opportunity to couple RDI with adjusted horticultural management not only to reduce water consumption but also to address two critical health issues facing the industry—agricultural burning and dust during harvest. Again working in the southern San Joaquin Valley and supported by the California Almond Board, we tested various RDI regimes ranging from water savings of 15 to almost 50 percent of potential orchard ET. We showed that mild stress over most of the season can be imposed with little negative influence on production and substantial water savings. However, a potentially more significant finding involved the RDI regimes that imposed moderate to severe preharvest (April to July) stress. These strategies reduced vegetative growth (canopy size) and individual kernel weight but had no influence on fruit load; the smaller, more compact trees had higher fruiting density (nuts per unit of canopy volume) than fully irrigated trees. Thus, one could increase the planting density (trees/acre), thereby increasing total nut production (number/acre) compared with conventionally planted and irrigated trees. The downside is that fruit size would be lower, which may somewhat decrease the value of the nuts. On the other hand, the need to prune trees would be much less, reducing the amount of pruning and burning.
Growers currently mechanically shake trees at harvest and leave the nuts on the ground to dry for 7 to 10 days before they are swept up. The sweeping and mechanical collection can create dust and related health concerns. Our research showed that preharvest stress can accelerate hull splitting, allowing for an earlier harvest, which benefits growers in a number of ways; earlier hull split allows the nuts to dry more completely on the tree prior to mechanical tree shaking. We believe that this presents the option of growers harvesting directly from the tree into nut catching machines, as is done currently in pistachio and prune orchards. This would eliminate the dust and other problems associated with nuts drying on the ground, such as ant damage and soil-borne bacteria infection.

Winegrapes is another crop where stress can substantially improve fruit quality. The irrigation of winegrapes was against the law in some European countries, such as Spain, until recently because of real or perceived negative irrigation-related impacts on wine quality. Some stress, however, is beneficial as it can reduce berry size, thereby increasing the ratio of skin to fruit volume. This is important to wine makers since the skin contains constituents important in wine color, taste, and chemical make-up.

Using our research and that of others and conservative estimates of current practices in orchards and vineyards, we have calculated a range of water savings for the major tree crops and winegrapes in California. These estimates are based on RDI regimes that do not reduce grower profits. One tree crop, walnuts, is excluded since we have no data showing that RDI can be successful although further research is planned. Water savings on the low end, those that we believe are currently achievable, total about 1 million acre-feet (see Table 1). If we include RDI adoption coupled with adjusted horticultural practices, such as the higher almond density plantings and improved, more precise methods of identifying tree stress, we believe that 1.5 million acre-feet can be saved. We are currently conducting research on developing electronic sensors that can accurately detect tree stress thus allowing the management of RDI strategies with precision and without risks. Today’s farming economy has resulted in the steady conversion of relatively low-value row crop land into higher profit orchards and vineyards. This process only enhances the scale of potential RDI adoption. Achieving the promise of RDI depends on growers recognizing the benefits of managed water stress. This requires demonstrating on a large scale that RDI can be successful in their terms—profits are maintained or increased—and that the higher level of irrigation management required is within the ability of on-farm personnel. We believe that RDI in orchards and vineyards could be a key component in this state’s effort to meet the growing demand for water and at the same time, preserve and protect permanent crop production.

### Table 1

<table>
<thead>
<tr>
<th>Crop</th>
<th>Bearing Acreage (acres)</th>
<th>Estimated Savings (inches)</th>
<th>Range of Water Savings (acre-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almonds</td>
<td>530,000</td>
<td>8 to 14</td>
<td>424,000 to 615,000</td>
</tr>
<tr>
<td>Winegrapes</td>
<td>490,000</td>
<td>8 to 12</td>
<td>320,000 to 490,000</td>
</tr>
<tr>
<td>Citrus</td>
<td>244,000</td>
<td>6 to 8</td>
<td>122,000 to 145,000</td>
</tr>
<tr>
<td>Pistachios</td>
<td>78,000</td>
<td>10 to 12</td>
<td>65,000 to 78,000</td>
</tr>
<tr>
<td>Prunes</td>
<td>76,000</td>
<td>6 to 12</td>
<td>36,000 to 75,000</td>
</tr>
<tr>
<td>Peaches</td>
<td>70,000</td>
<td>4 to 8</td>
<td>23,000 to 47,000</td>
</tr>
<tr>
<td>Olives</td>
<td>36,000</td>
<td>6 to 10</td>
<td>10,000 to 30,000</td>
</tr>
<tr>
<td>Apples and Pears</td>
<td>49,000</td>
<td>4 to 8</td>
<td>16,000 to 33,000</td>
</tr>
<tr>
<td>Walnuts</td>
<td>16,000</td>
<td>Unknown</td>
<td>Unknown</td>
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<tr>
<td>Total</td>
<td>1,759,000</td>
<td>52 to 84</td>
<td>1,026,000 to 1,525,000</td>
</tr>
</tbody>
</table>
SIMETAW (Simulation of Evapotranspiration of Applied Water)

By Richard Snyder, Morteza Orang, Shu Geng, Scott Matyac and Sara Sarreshteh, UC Davis and DWR
Simulation of Evapotranspiration of Applied Water
By Richard L. Snyder¹, Morteza N. Orang², Shu Geng³, J. Scott Matyac⁴, and Sara Sarreshteh¹

The Simulation of Evapotranspiration of Applied Water (SIMETAW) simulates weather data from monthly climate data and estimates reference evapotranspiration (ET₀) and crop evapotranspiration (ETc) with the simulated data. In addition, simulated daily rainfall, soil water holding characteristics, effective rooting depths, and ETc are used to determine effective rainfall and to generate hypothetical irrigation schedules to estimate the seasonal and annual evapotranspiration of applied water (ETaw), where ETaw is an estimate of the crop evapotranspiration minus any water supplied by effective rainfall. SIMETAW allows one to investigate how climate change may affect water demand in California. All ETaw calculations are done on a daily basis, so the estimation of effective rainfall and, hence, ETaw is greatly improved over earlier methods. In addition, the use of the widely adopted Penman-Monteith equation for reference evapotranspiration (ET₀) and improved methodology to apply crop coefficients for estimating crop evapotranspiration is used to improve ETaw accuracy.

Methodology

Weather Simulation

Weather simulation models are often used in conjunction with other models to evaluate possible crop responses to environmental conditions. One important response is crop evapotranspiration (ETc). Crop evapotranspiration is commonly estimated by multiplying reference evapotranspiration by a crop coefficient. In SIMETAW, daily data are used to estimate reference evapotranspiration. Rainfall data are then used with estimates of ETc to determine ETaw. One can either use raw or simulated daily data for the calculations.

Rainfall

Characteristics and patterns of rainfall are highly seasonal and localized, it is difficult to create a general, seasonal model that is applicable to all locations. Recognizing the fact that rainfall patterns are usually skewed to the right toward extreme heavy amount and that rain status of the previous day tends to affect the present day condition, a gamma distribution and Markov chain modeling approach was applied to described rainfall patterns for periods within which rainfall patterns are relatively uniform (Gabriel and Neumann 1962, Stern 1980, Larsen and Pense 1982, Richardson and Wright 1984). This approach consists of two models: two-state, first order Markov chain and a gamma distribution function. These models require long-term daily rainfall data to estimate model parameters. SIMETAW, however, uses monthly averages of total rainfall amount and number of rain days to obtain all parameters for the Gamma and Markov Chain models.

Wind Speed

The simulation of wind speed is a simpler procedure, requiring only the gamma distribution function as described for rainfall. Although using a gamma distribution provides good estimates of extreme values of wind speed, there is a tendency to have some unrealistically high wind speed values generated for use in

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ET_o calculations. Because wind speed depends on atmospheric pressure gradients, no correlation between wind speed and the other weather parameters used to estimate ET_o exists. Therefore, the random matching of high wind speeds with conditions favorable to high evaporation rates leads to unrealistically high ET_o estimates on some days. To eliminate this problem, an upper limit for simulated wind speed was set at twice the mean wind speed. This is believed to be a reasonable upper limit for a weather generator used to estimate ET_o because extreme wind speed values are generally associated with severe storms and ET_o is generally not important during such conditions.

**Temperature, Solar Radiation, and Humidity**

Temperature, solar radiation, and humidity data usually follow a Fourier series distribution. Therefore, the model of these variables may be expressed as:

\[ x_{ki} = \mu_{ki} (1 + \delta_{ki} C_{ki}) \]

where \( k = 1, 2 \) and 3 (\( k=1 \) represents maximum temperature; \( k = 2 \) represents minimum temperature; and \( k =3 \) represents solar radiation), \( \mu_{ki} \) is the estimated daily mean, and \( C_{ki} \) is the estimated daily coefficient of variation of the \( i^{th} \) day, \( i = 1, 2, \ldots, 365 \) and for the \( k^{th} \) variable.

SIMETAW simplifies the parameter estimation procedure of Richardson and Wright (1984), requiring only monthly means as inputs. From a study of 34 locations within the United States, the coefficient of variability (CV) values appear to be inversely related to the means. The same approach is used to calculate the daily CV values. In addition, a series of functional relationships were developed between the parameters of the mean curves and the parameters of the coefficient of variation curves, which made it possible to calculate \( C_{ki} \) coefficients from \( \mu_{ki} \) curves without additional input data requirement.

**Simulation Accuracy**

Nine years of daily measured weather data (1990–1998) from the California Irrigation Management Information System (CIMIS) in Davis were used in the model to simulate 30 years of daily weather data. The weather data consist of \( R_s, T_{max}, T_{min}, \) wind speed, \( T_{dew} \), and rainfall. The weather data simulated from SIMETAW were compared with the data from CIMIS. Figures 1, 2, and 3 show that \( R_s, T_{max}, \) and rainfall values predicted from SIMETAW were well correlated with those values obtained from CIMIS. Similar results were observed for \( T_{min} \), wind speed, and \( T_{dew} \) data.
Figure 1. Comparison of Measured and Simulated Daily Solar Radiation Data at Davis, California

Figure 2. Comparison of Measured and Simulated Maximum Air Temperature Data at Davis, California
Reference Evapotranspiration Calculation

Reference evapotranspiration ($ET_o$) is estimated from daily weather data using a modified version of the Penman-Monteith equation (Allen and others 1999, Walter and others 2000, Itenfisu and others 2000). The equation is:

$$ET_o = \frac{0.408 \Delta (R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34 u_2)}$$  \hspace{1cm} (2)$$

where $\Delta$ is the slope of the saturation vapor pressure at mean air temperature curve (kPa °C$^{-1}$), $R_n$ and $G$ are the net radiation and soil heat flux density in MJ m$^{-2}$d$^{-1}$, $\gamma$ is the psychrometric constant (kPa °C$^{-1}$), $T$ is the daily mean temperature (°C), $u_2$ is the mean wind speed in m s$^{-1}$, $e_s$ is the saturation vapor pressure (kPa) calculated from the mean air temperature (°C) for the day, and $e_a$ is the actual vapor pressure (kPa) calculated from the mean dew point temperature (°C) for the day. The coefficient 0.408 converts the $R_n - G$ term from MJ m$^{-2}$d$^{-1}$ to mm d$^{-1}$, and the coefficient 900 combines several constants and converts units of the aerodynamic component to mm d$^{-1}$. The product 0.34 $u_2$ in the denominator is an estimated ratio of the 0.12-m tall canopy surface resistance ($r_c=70$ s m$^{-1}$) to the aerodynamic resistance ($r_a=205/u_2$ s m$^{-1}$). It is assumed that the temperature, humidity, and wind speed are measured between 1.5 m (5 ft) and 2.0 m (6.6 ft) above the grass-covered soil surface. For a complete explanation of the equation, see Allen and others (1999).
If only temperature data are available, then SIMETAW calculates daily ET₀ using the Hargreaves-Samani equation. The equation may be written:

\[ ET₀ = 0.0023 \left(T_c + 17.8\right) R_a (T_d)^{1/2} \]  

(3)

Where \( T_c \) is the monthly mean temperature (degrees centigrade), \( R_a \) is the extraterrestrial solar radiation expressed in mm/month, and \( T_d \) is the difference between the mean minimum and mean maximum temperatures for the month (degrees centigrade).

If pan data are used in the program, then the program automatically estimates daily ET₀ rates using a fetch value (that is, upwind distance of grass around the pan). The approach in the SIMETAW provides a simple method to estimate ET₀ from Epan data without the need for wind speed and relative humidity data.

**Verification of the Simulated Reference Evapotranspiration**

As a final verification of the SIMETAW model, we compared our model predictions of ET₀ with number of years of estimated daily ET₀ data from CIMIS at Davis, Oceanside, and Bishop. The performance of our model ET₀ predictions was evaluated at sites influenced by coastal and windy desert climates. Figures 4, 5, and 6 compare daily mean ET₀ estimates of SIMETAW and CIMIS averaged over the period of records. As seen in the figures, a close agreement exists between CIMIS-based estimates of ET₀ and those of the SIMETAW model. Bishop is influenced by a windy desert environment on the eastern side of the Sierra Nevada. Oceanside is a coastal site in San Diego County. Davis is in the Central Valley, which is characterized during summer by clear, hot, dry days with strong, cooling southwest winds in the afternoons.
Figure 5
Comparison of Estimated and Simulated Reference Evapotranspiration Data at Oceanside, California

- Averaged over 14 years of estimated data from CIMIS
- Averaged over 14 years of simulated data from SIMETAW

Figure 6
Comparison of Estimated and Simulated Reference Evapotranspiration Data at Bishop, California

- Averaged over 15 years of data from CIMIS
- Averaged over 15 years of simulated data
**Input Climate Data**

Either daily or monthly climate data are used to determine $ET_{aw}$ in SIMETAW. Daily data can come from CIMIS or from a non-CIMIS data source as long as data are in the correct format. After reading the data, $ET_{aw}$ can be calculated directly from the raw daily data. In addition, the monthly means can be calculated from the daily files, and then daily data are generated using the simulation program. Daily data are input directly, so the calculation of monthly data for use in simulation of daily data is unnecessary. However, it was included to test whether similar results were obtained using raw or simulated data.

The monthly data can be read from a file or calculated from daily CIMIS or non-CIMIS data files, or from some other source. The monthly data file must have the proper comma-delimited format. SIMETAW generates daily weather data for a specified period of record from the monthly data.

SIMETAW either generates a daily data file from monthly data or uses a raw data file consisting of daily solar radiation, maximum, minimum, and dew point temperature and wind speed for calculating daily $ET_{o}$. After calculating $ET_{o}$ if the data were generated, the program sorts the rainfall data within each month to force a negative correlation between rainfall amount and $ET_{o}$ rate. Only the rainfall dates are sorted, and there is no change in the dates for the weather and $ET_{o}$ data. Furthermore, the program can simulate daily $ET_{o}$ data directly from monthly means of $ET_{o}$ and $E_{pan}$ data.

**Crop Coefficients**

While reference crop evapotranspiration accounts for variations in weather and offers a measure of the "evaporative demand" of the atmosphere, crop coefficients account for the difference between the crop evapotranspiration and $ET_{o}$. The main factors affecting the difference are (1) light absorption by the canopy, (2) canopy roughness, which affects turbulence, (3) crop physiology, (4) leaf age, and (5) surface wetness. Because evapotranspiration (ET) is the sum of evaporation (E) from soil and plant surfaces and transpiration (T), which is vaporization that occurs inside the plant leaves, the components are best considered separately. When not limited by water availability, both transpiration and evaporation are limited by the availability of energy to vaporize water. During early growth of crops, when considerable soil is exposed to solar radiation, $ET_{c}$ is dominated by soil evaporation and the rate depends on whether or not the soil surface is wet. If a nearly bare-soil surface is wet, the $ET_{c}$ rate is slightly higher than $ET_{o}$, when evaporative demand is low, but it will fall to about 80 percent of $ET_{o}$ under high evaporation conditions. However, as a soil surface dries off, the evaporation rate decreases considerably. As a canopy develops, solar radiation (or light) interception by the foliage increases and transpiration rather than soil evaporation dominates $ET_{c}$. Assuming there is no transpiration-reducing water stress, light interception by the crop canopy is the main factor determining the $ET_{c}$ rate. Therefore, crop coefficients for field and row crops generally increase until the canopy ground cover reaches about 75 percent. For tree and vine crops the peak $K_{c}$ is reached when the canopy has reached about 70 percent ground cover. The difference between the crop types results because the light interception is somewhat higher for the taller crops.

**Crop Coefficient Estimation**

Crop coefficients are calculated using a modified Doorenbos and Pruitt (1977) method. The season is separated into initial (date A-B), rapid (date B-C), midseason (date C-D), and late season (date D-E) growth periods.
**Field and Row Crops**

Tabular default \( K_c \) values corresponding to important inflection points in Figure 7 are stored in the SIMETAW program. The value \( K_{c1} \) corresponds to the date B \( K_c \) (\( K_{cB} \)). For field and row crops, \( K_{c1} \) is used from date A to B. The value \( K_{c2} \) is assigned as the \( K_c \) value on date C (\( K_{cC} \)) and D (\( K_{cD} \)). Initially, the \( K_{cC} \) and \( K_{cD} \) values are set equal to \( K_{c2} \), but for tree and vine crops, the values for \( K_{cC} \) and \( K_{cD} \) are adjustable for the percentage shading by the canopy to account for sparse or immature canopies. During the rapid growth period, when the field and row crop canopy increases from about 10 percent to 75 percent ground cover, the \( K_c \) value changes linearly from \( K_{cB} \) to \( K_{cC} \). For deciduous tree and vine crops, the \( K_c \) increases from \( K_{cB} \) to \( K_{cC} \) as the canopy develops from leaf out on date B to about 70 percent shading on date C. During late season, the \( K_c \) changes linearly from \( K_{cD} \) on date D to \( K_{cE} \) at the end of the season. The values for \( K_{cB} \) and \( K_{cC} \) depend on the difference in (1) energy balance due to canopy density and reflective qualities, (2) crop morphology effects on turbulence, and (3) physiological differences between the crop and reference crop.

**Figure 7**

Hypothetical Crop Coefficient (\( K_c \)) Curve for Typical Field and Row Crops Showing Growth Stages and Percentages of the Season from Planting to Critical Growth Dates
Deciduous Tree and Vine Crops

Deciduous tree and vine crops, without a cover crop, have similar Kc curves but without the initial growth period (Figure 8). The season begins with rapid growth at leaf out when the Kc increases from KcB to KcC. The midseason period begins at approximately 70 percent ground cover. Then, unless the crop is immature, the Kc is fixed at KcC until the onset of senescence on date D (KcD=KcC=KcD). During late season, when the crop plants are senescing, the Kc decreases from KcD to KcE. The end of the season occurs at about leaf drop or when the tree or vine transpiration is near zero.

Figure 8
Hypothetical Crop Coefficient (Kc) Curve for Typical Deciduous Orchard and Vine Crops Showing Growth Stages and Percentages of the Season from Leaf Out to Critical Growth Dates
Correcting the Initial $K_c$ for Wetting Frequency

During the off-season and during initial crop growth, $E$ is the main component of ET. Therefore, a good estimate of the $K_c$ for bare soil is useful in estimating off-season soil evaporation and $E_T$ early in the season. A two-stage method for estimating soil evaporation presented by Stroosnijder (1987) and refined by Snyder and others (2000) is used to estimate bare-soil crop coefficients. As shown in Figure 9, this method gives $K_c$ values as a function of mean $ET_o$ and wetting frequency in days that are quite similar to the widely used bare soil coefficients published in Doorenbos and Pruitt (1977). In Figure 9 solid lines represent the model used in the SIMETAW, and dashed lines are from Doorenbos and Pruitt (1977). The soil evaporation model estimates crop coefficients for bare soil using the daily mean $ET_o$ rate and the expected number of days between significant precipitation ($P_i$) on each day of the year. Daily precipitation is considered significant when $P_i > 2 \times ET_o$.

![Figure 9: Crop Coefficient ($K_c$) Values for Nearly Bare-Soil Evaporation as Function of Mean $ET_o$ Rate and Wetting Frequency in Days](image-url)
Correcting the $K_c$ for Immature Trees and Vines

SIMETAW accounts for immaturity effects on crop coefficients for tree and vine crops. Immature deciduous tree and vine crops use less water than mature crops. The following equation is used to adjust the mature $K_c$ values ($K_{cm}$) as a function of percentage ground cover ($C_g$).

$$\text{If } \sin \left( \frac{C_g \pi}{70} \right) \geq 1.0 \text{ then } K_c = K_{cm} \sin \left( \frac{C_g \pi}{70} \right)$$

Correcting the $K_c$ for Immature Subtropical Orchards

For an immature orchard, the mature $K_c$ values ($K_{cm}$) are adjusted for their percentage ground cover ($C_g$) using the following criteria.

$$\text{If } \sin \left( \frac{C_g \pi}{70} \right) \geq 1.0 \text{ then } K_c = K_{cm} \text{ or else } K_c = K_{cm} \sin \left( \frac{C_g \pi}{70} \right)$$

Correcting for Cover Crops

With a cover crop, the $K_c$ values for deciduous trees and vines are higher. When a cover crop is present, 0.35 is added to the clean-cultivated $K_c$. However, the $K_c$ value is not allowed to exceed 1.15 or to fall below 0.90. SIMETAW allows beginning and end dates to be entered for two periods when a cover crop is present in an orchard or vineyard.

Field Crops with Fixed Crop Coefficients

Fixed annual $K_c$ values are possible for some crops with little loss in accuracy. These crops include pasture, warm-season and cool-season turf grass, and alfalfa averaged over a season. In the SIMETAW program, these field crops are identified as type-2 crops.
ET of Applied Water Calculations

The ET$_o$ data come from the "name.wrk" file, which is created from either input raw or simulated daily weather data. The K$_c$ values are based on the ET$_o$ data and crop, soil, and management specific parameters from a row in the ‘DAUnnn.csv’ file. During the off-season, crop coefficient values are estimated from bare-soil evaporation as previously described. It is assumed that all water additions to the soil come from rainfall and losses are only due to deep percolation. Rainfall runoff as well as surface water running onto a cropped field is ignored. Because the water balance is calculated each day, this assumption is reasonable.

During the off-season, if the soil water depletion (SWD) is less than the yield threshold depletion (YTD), ET$_c$ is added to the previous day’s SWD to estimate the depletion on the current day. However, the maximum depletion allowed is 50 percent of the PAW in the upper 30 cm of soil. If the SWD at the end of a growing season starts at some value greater than the maximum soil water depletion, then the SWD is allowed to decrease with rainfall additions but it is not allowed to increase with ET$_c$ (Figure 10). If half of the available water is gone from the upper 30 cm, it is assumed that the soil surface is too dry for evaporation. Once the off-season SWD is less than the maximum depletion, it is again not allowed to exceed the maximum off-season depletion.

If a crop is pre-irrigated, then the SWD is set equal to zero on the day preceding the season. If it is not pre-irrigated, then the SWD on the day preceding the season is determined by water balance during the off-season before planting or leaf out. It is assumed that the SWD equals zero on December 31 proceeding the first year of data. After that the SWD is calculated using water balance for the entire period of record.

During the growing season, the SWD depletion is updated by adding the ET$_c$ (or by subtracting ET$_c$ from the soil water content [SWC]) on each day (Figure 10). If rainfall occurs, SWD is reduced by an amount equal to the rainfall. However, the SWD is not allowed to be less than zero. This automatically determines the effective rainfall as equal to the recorded rainfall if the amount is less than the SWD. If the recorded rainfall is more than the SWD, then the effective rainfall equals the SWD. Irrigation events are given on dates when the SWD would exceed the YTD. It is assumed that the SWD returns to zero on each irrigation date. The ET$_{aw}$ is calculated both on a seasonal and annual basis as the cumulative ET$_c$ minus the effective rainfall. The calculations are made for each year over the period of record as well as an overall average over years. The results are output to a summary table.
Figure 10  Annual Water Balance for Cotton Showing Fluctuations in Soil Water Content (SWC) between Field Capacity (FC) and Maximum Depletion during Off-season and between FC and Yield Threshold Depletion (YTD) during Season

Davis - Corn - First year simulation
May 1 - Sep 30 with peak Kc = 1.05

Davis - Corn - Second year simulation
May 1 - Sep 30 with peak Kc = 1.05
General Applications

SIMETAW was written specifically to estimate ET_{aw} for calculating irrigation water requirements when water demand planning. However, the program has many additional applications. For hydrology the SIMETAW application can provide evapotranspiration boundary conditions for groundwater and surface water models, which can lessen the potential for floods and can improve the management of water banking, aquifers, dams and reservoirs, and sea water intrusion in the Sacramento-San Joaquin Delta. In addition the program can be used to help California growers obtain improved crop coefficients for use in irrigation management. Use of SIMETAW to determine water demand by region can help manage water transfers throughout California. Because the program generates many years of simulated weather data from monthly climate data, it can be used to study how changes in the monthly means may affect weather in the future. This can have implications for protection against frost, which causes more economic losses in the United States than any other weather-related phenomenon. Climatic changes in temperature, rainfall patterns, and humidity could all influence future daily weather conditions and could lessen or increase the probability of freezing temperatures. Changes in climate and their effect on daily weather can also influence air pollution within the state; SIMETAW can be used to simulate possible scenarios.

Air pollution is clearly a major problem in California, and SIMETAW could help identify an increased potential for major pollution events that could result from changes in rainfall patterns, temperature, etc. Another major problem in California is wildfire, which could worsen if the climate changes. SIMETAW can be used to study the impact of changes in monthly climate data on future weather conditions. This could impact biomass production in forests and rangeland, and changes in weather conditions could influence whether or not the natural ecosystems will experience more water stress and make them more prone to fire events. Of course, changes in the climate could impact human health because of effects on air pollution as well as temperature extremes. SIMETAW can provide scenarios of possible weather extremes resulting from changes in monthly climate data. SIMETAW can also be applied to refine the monthly mean ET_{aw} rates (in/day) of California ET_{aw} Zone map. In addition, SIMETAW can be used as a tool to fill in missing data points from long-term data sets, which could be helpful for developing rainfall-runoff models, etc. There is considerable research on the use of regulated deficit irrigation (RDI) to more efficiently use water in crop production, which could potentially decrease water demand. The SIMETAW program has a stress factor built-in to account for reductions in ET_{aw} due to the use of RDI.

More information on SIMETAW is available at DWR’s Web site:
www.waterplan.water.ca.gov/landwateruse/wateruse/Ag/wuagricultural.htm
References


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In many ways, this report is a continuation of work the Pacific Institute has been pursuing for more than a decade. In 1995, the Institute published a vision of sustainable water use in California, entitled “California Water 2020.” This report received an enormous amount of attention for proposing that there were affordable, attainable solutions to the state’s perennial water disputes and challenges; in a lead editorial, the San Francisco Chronicle called it “a common sense plan” for the future. Yet traditional water planners are reluctant to explore alternative visions of the future. The most recent draft California Water Plan is a case in point—several scenarios were developed for the year 2030, yet none of them tried to evaluate what a truly water-efficient future could look like, instead pushing that analysis off to 2010. We believe such a future is possible, and even desirable. And we believe that thinking about what an efficient future might look like, and how to get there, are worthy and urgent goals.

Funding for this study has come from a variety of sources that believe the Pacific Institute should have the freedom to explore unusual water paths and that solutions to water problems are possible. We thank them, especially the Flora Family Foundation, the Charles Evan Hughes Memorial Fund, and the William and Flora Hewlett Foundation. Their generosity and foresight have given us the flexibility to respond when and where we think it most important and necessary.

We would also like to thank all those who have offered ideas, data, information, and comments on the report, including Nick Di Croce, Lloyd Fryer, Alex Hildebrand, Scott Matyac, Mindy McIntyre, Jonas Minton, Bob Wilkinson, numerous members of the California Water Plan Public Advisory Committee, DWR staff, and an anonymous reviewer. We would like to thank Gary Wolff for fruitful discussions about the economics of conservation and efficiency. We would also like to thank Nicholas Cain of the Institute and Joe Sadusky and Bryan Kring for their help in editing, formatting, and producing the report.

All errors are, of course, our own.
ABOUT THE PACIFIC INSTITUTE

The Pacific Institute is dedicated to protecting our natural world, encouraging sustainable development, and improving global security. Founded in 1987 and based in Oakland, California, we provide independent research and policy analysis on issues at the intersection of development, environment, and security. Our aim is to find real-world solutions to problems like water shortages, habitat destruction, global warming, and conflicts over resources. We conduct research, publish reports, recommend solutions, and work with decision makers, advocacy groups, and the public to change policy. More information about the Institute, staff, directors, funders, and programs can be found at www.pacinst.org and www.worldwater.org.

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EXECUTIVE SUMMARY

WHAT COULD CALIFORNIA’S WATER situation look like in the year 2030—twenty-five years from now? The answer is, almost anything: from shortage and political conflict to sufficiency and cooperation. California water planners regularly prepare projections of supply and demand as part of the California Water Plan process, but these projections have never included a vision of a truly water-efficient future, where California’s environmental, economic, and social water needs are met with smart technology, strong management, and appropriate rates and incentives. A water-efficient future is possible; indeed, it is preferable. We present a “High Efficiency” scenario here in which Californians maximize our ability to do the things we want, while minimizing the amount of water required to satisfy those desires.

Under a High Efficiency scenario, total human use of water in California could decline by as much as 20 percent while still satisfying a growing population, maintaining a healthy agricultural sector, and supporting a vibrant economy. Some of the water saved could be rededicated to agricultural production elsewhere in the state; support new urban and industrial activities and jobs; and restore California’s stressed rivers, groundwater aquifers, and wetlands.

This High Efficiency scenario is not a prediction for the future, but a desirable and achievable possibility—a vision of California in which improvements in water-use efficiency are considered the primary tools for reducing human pressures on the state’s precious water resources. Can such an efficient water future be achieved? Yes, given appropriate attention and effort, California’s water-use practices can be substantially modified over the next quarter century, just as they have over the past 25 years. Will such a future be achieved? That is a question that only the public and our elected officials can answer. We hope this analysis will contribute to the dialogue on how to design and implement appropriate strategies for moving along this more efficient path.
EXECUTIVE SUMMARY

Highlights

• A water-efficient future for California is possible.

• The Pacific Institute High Efficiency scenario shows that water use in 2030 could be 20 percent below 2000 levels, even with a growing population and a healthy economy.

• A water-efficient future is achievable, with no new inventions or serious hardships.

• Implementing serious efficiency improvements requires actions on the part of legislators, water managers, water districts and agencies, farmers, corporations, and all individuals.

• The sooner such actions are taken, the easier the transition to an efficient future will be.

Water Scenarios

The State of California has routinely prepared water scenarios and projections as part of long-term water planning. The principal tool for water planning at the state level is the California Water Plan, a regular analysis published by the California Department of Water Resources (DWR). The newest version of the Plan was released for public review in May 2005. Figure ES-1 shows projections of future human water demands from the California Water Plans over the past four decades, together with an estimate of actual water use. As this figure shows, official scenarios routinely project substantial increases in water use over time, often far in excess of the use that actually materializes.

Figure ES-1
Projections of Total Water Demands in California

Each Water Plan Update makes one or more projections of future demand. The number next to each projection refers to the year in which the projection was made. The 1974 Water Plan Update evaluated four scenarios for future demand, represented by Roman numerals I-IV. The 2005 Water Plan Update evaluates three scenarios of future demand: Current Trends (CT), More Resource Intensive (MRI), and Less Resource Intensive (LRI). 1

1 The California Water Plan is also known as Bulletin 160.
The 2005 Draft California Water Plan introduced a long-term effort to develop multiple scenarios of water supply and demand. To initiate this effort, the 2005 Water Plan staff and Public Advisory Committee developed three scenarios of future water demand in California. The three scenarios developed for the 2005 version provide estimates of the quantity of water that would be used in 2030 under specified demographic, economic, agricultural, and water management conditions. Figure ES-2 and ES-3 show urban and agricultural water use for the three DWR scenarios for 2030, compared to current (year 2000) levels. The Department of Water Resources describes these scenarios as follows:

**Current Trends.** Water demand based on “current trends with no big surprises.”

**Less Resource Intensive.** “California is more efficient in 2030 water use than today while growing its economy within much more environmentally protective policies.”

**More Resource Intensive.** “California is highly productive in its economic sector. Its environment, while still important, is not the state’s first priority for water management decisions. Water use in this scenario is less efficient in 2030 than it is in [the other] scenarios …” (DWR 2005).

A close analysis reveals that these scenarios are not radical, or even dramatic, departures from past analyses. All three DWR scenarios include only modest efficiency improvements achievable with current policies and programs. DWR has stated their intention to evaluate various “response packages,” including greater water-use efficiency efforts, for the 2010 California Water Plan. We support that effort, but believe it is critical to begin evaluating, and implementing, stronger water-conservation and efficiency programs now. Waiting another five to ten years will make solving California’s complex water challenges more difficult and expensive.
EXECUTIVE SUMMARY

Even the most efficient DWR scenario shows increases in urban water use by 2030 of nearly 1.5 million acre-feet (MAF), and the most inefficient scenario projects urban demand to increase by a huge, and most likely unattainable, 5.8 MAF. All three scenarios project slight (5 to 10 percent) decreases in agricultural water use over the next 30 years, similar to the agricultural forecasts of the last three official California Water Plans.

We believe it is possible to foresee—and move toward—a different future. We envision a future in which California water use is highly efficient, permitting us to maintain a healthy economy and healthy ecosystems while reducing overall water use. In an attempt to describe this future, we present here an alternative, High Efficiency scenario.

Highlights of the Pacific Institute
High Efficiency Scenario

A water-efficient future for California is possible.

According to our High Efficiency scenario, there is great potential for improving agricultural and urban water-use efficiency. The scenario was produced with the same model used by DWR to generate their three future demand scenarios for the 2005 California Water Plan. Our scenario adopted the same projections of population, housing distribution, agricultural land area, crop type and distribution, and income projections used by DWR. For the Pacific Institute High Efficiency scenario, we modified the assumptions about the potential for improving efficiency of water use based on more comprehensive implementation of existing technology and application of historical trends for water prices. Our analysis suggests that a water-efficient future is possible.
The Pacific Institute High Efficiency scenario shows that water use in 2030 could be 20 percent below 2000 levels, even with a growing population and a healthy economy.

The Pacific Institute High Efficiency scenario is based on widespread adoption of existing water-efficiency technologies, not on the invention of new efficiency options, and on different estimates of water prices and trends. Figures ES-4 and ES-5 show total human water demands generated by the DWR Current Trends and Pacific Institute High Efficiency scenarios between 2000 and 2030, along with estimated actual water use during the latter half of the 20th century. Overall statewide agricultural and urban water demand is projected to decline in both scenarios, but in the Pacific Institute High Efficiency scenario total human use of water declines by 8.5 MAF—a reduction of around 20 percent from 2000.

Figure ES-4
Statewide Trend in Total Urban and Agricultural Water Demand Between 1960 and 2000, with Projections to 2030 in the Current Trends and High Efficiency Scenarios

Figure ES-5
Urban and Agricultural Water Demand Change (2000-2030) by Geographic Region in the Current Trends and High Efficiency Scenarios

North
Central
South
EXECUTIVE SUMMARY

A water-efficient future is achievable, with no new inventions or serious hardships.

Urban water use in the Pacific Institute High Efficiency scenario falls 0.5 MAF per year below actual 2000 levels and far below the 2030 Current Trends scenario of DWR. Demand for water in California’s urban sector between 2000 and 2030 is projected to increase by 3.0 MAF in the Current Trends scenario and decrease by 0.5 MAF in the Pacific Institute High Efficiency scenario (see Figure ES-6), a difference in urban water use of over 3.5 MAF annually.

Total agricultural water use declines more than 20 percent from actual year 2000 water use in the Pacific Institute High Efficiency scenario as farmers move to more efficient irrigation methods, without reducing crop area or changing crop type from the official state Current Trends scenario. Figure ES-7 shows actual and projected agricultural water demand between 1960 and 2030 for the Current Trends and High Efficiency scenarios. Agricultural water demand is projected to decline from 2000 by ten percent (3.5 MAF) and 23 percent (8 MAF) in these two scenarios, respectively, while overall crop production remains relatively unchanged. The difference between the scenarios—approximately 4.5 MAF in water savings—is due to assumptions about irrigation technology and agricultural water prices. Even though total water use is projected to drop substantially in our scenario, total income to farmers remains effectively unchanged and total value per acre in the High Efficiency scenario slightly increases.
Reaching the Pacific Institute High Efficiency future is possible, but will require serious effort on the part of California policy makers, water managers, and the public.

We believe that this efficient future is achievable, with no new inventions or serious hardships. Indeed, we believe this future is likely to be better for all Californians and the environment. But implementing serious efficiency improvements requires actions on the part of legislators, water managers, water districts and agencies, farmers, corporations, and all individuals.

The sooner such actions are taken, the easier the transition to an efficient future will be.

Delaying action on water-conservation and efficiency increases the pressure to find, build, or buy new expensive and environmentally damaging sources of water supply. In California, and much of the rest of the western United States, such sources of supply are increasingly scarce or controversial. While we do not believe a highly efficient future is necessarily easy to achieve, we think it will be easier, faster, and cheaper than any other option facing us.

Actions to Be Taken Now

Pricing policies that subsidize the inefficient use of water should be eliminated.

- Ensure that urban and agricultural water rates reflect the true cost of service, including non-market costs.
- Phase out water subsidies on the Central Valley Project, especially for low-valued, water-intensive crops.
- Implement new rate structures that encourage efficient use of water.
- Avoid inappropriate subsidies for new water-supply options.
EXECUTIVE SUMMARY

Efforts to promote the use of water-efficient technologies and practices should be greatly expanded, in both the urban and agricultural sectors.

- Set new water-efficiency standards for residential and commercial appliances, including toilets, washing machines, dishwashers, showers, and faucets.
- Offer comprehensive rebates, including both energy and water rebates, for the purchase of water-efficient appliances.
- Require water-efficient appliances to be “retrofit on resale” for existing homes.
- Revise and expand “Best Management Practices” for urban and agricultural water agencies.
- Make “Best Management Practices” mandatory and enforceable.
- Expand development and deployment of efficient irrigation technologies and new crop types.

Legislative, regulatory, and administrative support should be given to those water transfers that improve water-use efficiency, while promoting the overall well-being of rural communities.

- Implement programs to permit water saved through efficiency improvements to be transferred and marketed, but reduce adverse impacts on rural communities and the environment from such transfers.
- A statewide system of water data monitoring and exchange should be created, especially for water use.
- Collect and make publicly available comprehensive water-use data for all users.
- Design and implement comprehensive local groundwater monitoring and management programs statewide.

Educational programs on water use, and on the potential for water-use efficiency, should be expanded.

- Label all appliances with efficiency ratings.
- Expand water-efficiency information and evaluation programs in the Agricultural Extension Services and other agricultural outreach efforts.
- Develop on-line data collection and dissemination networks to provide farmers with immediate meteorological and hydrological information on climate, soil conditions, and crop water needs.
Better combined land and water planning is needed.

- Demonstrate a secure, permanent supply of water before new urban and suburban developments are approved.
- Demonstrate water-efficient housing designs before developments are approved.
- Protect high-quality agricultural land and related watersheds from urbanization.

Conclusions

The two scenarios described here—the DWR Current Trends and the Pacific Institute High Efficiency scenarios—offer different views of urban and agricultural water use in 2030. They are the result of making different assumptions about a range of water efficiency options, policies, technologies, and decisions. Neither scenario is a prediction. How much water will be needed and used to meet urban and agricultural demands in 2030 is unknowable and uncertain, because it depends on a vast array of factors. Some of these factors are partly or completely out of the hands of Californians, such as decisions about crop production in other countries, the extent and severity of climate changes, technological developments, national policies around efficiency standards or pricing of water from federal projects, and so on.

Other factors, however, are well within our ability to influence, and some of these factors will have a huge effect on future water demands. We believe a water-efficient future is possible; indeed we believe such a future is preferable. Ultimately, which future we reach depends upon what water policies are implemented over the coming years. Experience has shown that efforts to improve water-use efficiency are consistently successful and cost-effective. If California put as much time, money, and effort into water-efficiency programs as has gone into traditional water supply development, a high efficiency future could be readily achieved—with benefits to our economy, environment, and health.
Future Quantitative Analysis for California Water Planning
By Ken Kirby, Active Curiosity Inc.
Future Quantitative Analysis for California Water Planning

by Kenneth Kirby, Active Curiosity, Inc.

Introduction

Past California water plan updates were intended for water managers and those involved in making state water infrastructure decisions. However, resource issues have become more interconnected, and land use and resource planners increasingly consider water management in their analyses and decisions. Requests are increasing for the water plan to address questions that go beyond a gap analysis of water use and supply. This article describes the short-term and long-term activities being pursued by the State Department of Water Resources to improve analysis performed for the water plan.

Analytical tool and data development for California water has not kept pace with the growing public awareness of the complexity and interaction between water-related issues. A critical issue facing California is the need for better data and tools to produce useful information about environmental objectives, water quality, economic performance, social equity objectives, and groundwater and surface water interaction. Also, there is a need to integrate more effectively details associated with regional and local planning into the studies being conducted from a statewide perspective. For planning purposes, these tools and data must help planners predict a range of plausible future conditions and interactions on the statewide level and compare outcomes of potential management actions. Many of the current tools have been developed and applied in a comparative role, and their suitability for a predictive role can vary widely. Even so, planners rely on the state to provide data and information that help to describe and analyze plausible future scenarios, which they can use for planning purposes.

State government must play a leadership role in developing the overall strategy for California water management from a systemwide perspective. No tools currently exist that can be used for both predictive and comparative studies integrating all of the interactions described above. Local land use planners also rely on water management information for which the State can provide insights. Work on the water plan is being coordinated with the CALFED Storage Investigation’s Common Assumptions and Water Use Efficiency Comprehensive Analysis studies. Staff from these planning processes have been meeting to coordinate information and discuss study assumptions and quantitative methodologies.

DWR initiated the Analytical Tools and Data Work Group (formerly known as the Modeling Work Group), which consists of advisory committee members, stakeholders interested in modeling, technical consultants for other planning processes, and staff from the California Bay Delta Authority and DWR. Since 2001 this work group has met more than 16 times to discuss the roles, validation, and confidence in available tools and data and the ability to perform studies and analyses for Update 2005. To address concerns, a series of workshops were convened that focused on the fundamental questions the water plan should address in general and the technical information that the tools are expected to provide in particular. Future work with our stakeholders will consider these issues including quality assurance, transparency, accessibility of information, external review processes, and integrating issues like water quality, economics, the environment, groundwater, and land use.
The work outlined in this article aims to improve the quantitative understanding of California water and of how to employ analytical tools to aid in developing and comparing solutions to California’s water problems and decision-making. The work proposed here for data and tools is consistent with the three-phased approach for producing California Water Plan Update 2005, outlined in Chapter 1, Volume 1. The work on tools and data in the three-phased approach includes:

- **Phase 1:** Recommend the short- and long-term work as described in this article.
- **Phase 2:** Select appropriate analytical tools, data, and assumptions to provide technical analyses.
- **Phase 3:** Apply the analytical tools selected in Phase 2 and interpret results to evaluate performance of several response strategies on a regional basis given three or four plausible future scenarios. Scenarios represent future base or no-action conditions water managers could face that are beyond their control, like population growth and land use changes.

### Technical Information Needs

The desire to address various crosscutting issues such as environmental objectives, land-use planning, and economics in different scenarios in this water plan and other ongoing planning efforts requires more technical and quantitative information than for previous water plans. Many discussions with the Analytical Tools and Data Work Group and the Advisory committee have focused on the specific information needed to satisfy the broad objectives of the water plan’s new planning framework (see Chapter 1, Volume 1) and disclosure of all technical assumptions.

In addition to developing the new planning framework, the advisory committee and DWR invited land use and resource planners, academics, policy analysts, and technical experts to build on and affirm advisory committee understanding about issues critical for the water plan to address. These conversations have been captured in mind maps that represent a web of relationships and ideas. The mind maps are in the Technical Guide (Volume 5). In addition to traditional information needs related to evaluating water supply and demand, water plan users seek good information related to ecosystem wants and demands; economic relationships, such as the effect of tiered water pricing on demand or economic effects of transfers; water quality, such as reusing wastewater and matching water quality to use; social equity issues, such as public trust and environmental justice concerns; water use efficiency; and groundwater and surface water interaction. Further, the water plan could play a critical role linking water and land use management decisions. Land use planners need useful information about water demand as it relates to compact development and growth.

### Planned Analyses

For Update 2005 and the next update the phased work plan includes three groups of analyses:

1. **Water Portfolios** that describe the available water sources, movement and uses by region, under several recent hydrologic conditions using actual data (1998, 2000, and 2001 in Update 2005, 1999, 2002, and 2003 in the next update). The portfolios present historic observable data and some of the causal relationships between sources and uses of water as it moves in California.

2. **Future Scenarios** that describe plausible base conditions of water use and water supply throughout California in 2030. The scenarios are intended to provide quantitative estimates of future water conditions based on existing observable data and defined causal relationships.
3. **Alternative Response Packages** of water resource management strategies that are designed to improve performance of the water management system with regards to system objectives. The expected system performance with each alternative response package in place will be analyzed under each plausible future scenario. The performance of each alternative response package will be compared using quantitative evaluation criteria. A list of evaluation criteria is shown in Table 4-5, Chapter 4 of Volume 1.

**Water Portfolios**

The water portfolios provide comprehensive water balance and flow diagrams for 10 hydrologic regions covering the entire state. The flow diagram characterizes the hydrologic cycle and documents sources of water, such as precipitation and inflows into the state, and tracks the water as it flows through many different uses to its ultimate destination. Since data for some categories are not measured for many regions of the state, the current water portfolios show gaps. Identifying additional data collection and management activities in Update 2005 is an important step in improving the water portfolios for future water plan updates.

There are a number of categories in the flow diagram where data are simply not available or very resource intensive to compile. Significant data gaps include:

- statewide land use data, including native vegetation, urban footprints, non-irrigated agriculture, and irrigated agriculture
- total groundwater natural recharge
- groundwater subsurface inflow and outflow
- groundwater extractions and recharge
- evaporation from land surfaces
- evapotranspiration from native vegetation and non-irrigated agriculture
- total stream flow
- total direct diversions
- natural and incidental runoff
- return flows
- conveyance losses

There are a number of data items necessary to calculate or estimate these categories. Some of the major data items needed to complete the flow diagram and water balances consist of more detailed and accessible land and water use information including information to separate applied water use versus consumptive water use. The major data items are:

- water source of supply information
- outflow data
- groundwater level data
- groundwater recharge rates
- natural riparian water requirements
- evapotranspiration rates for all types of vegetation
- detailed return flow information
- more detailed physical information about all watersheds, water systems, and groundwater basins in the state
Data are currently available only for some regions. For example, methodologies and data to estimate natural runoff are available for regions like the Sacramento River and the San Francisco Bay Region where the Delta is a control point. But in areas like the South Coast Region with no control point and substantial groundwater, the natural runoff is nearly impossible to estimate. In addition to natural obstacles, existing data are not easily aggregated or disaggregated to provide convenient access for all areas of interest, and resource constraints limit extensive data collection and management necessary to quantify and track all the water in the state.

State government should guide California in expanding data collection and management programs that already exist. Data needs are characterized by the need for detail (data monitoring in more geographic locations and for particular categories), to digitize (common electronic methods), and for a comprehensive database.

**Future Scenarios**

Developing quantitative estimates for several future scenarios requires using available data and presumed relationships. A list of key factors affecting future use and supply scenarios in 2030 is shown in Table 4-1 in Chapter 4 of Volume 1. Some examples of these factors include total population, population density, land use, and energy costs. Each of these factors must be predicted or quantified, and like the data needed for the water portfolios, the availability and resolution of data needed for the future scenarios varies widely. While the key factors have been identified, much work still exists to reach agreement on the relationships between the factors and the methods that will be used to quantify the factors as described in Table 4-1. The preliminary scenarios presented in Chapter 4 illustrate how this can be done, but the details for future scenarios will be revisited during the next update. Some examples of the significant complexities in predicting factors such as groundwater storage or surface water storage conditions in 2030 are shown in the Factor Complexity Diagrams in the Technical Guide.

Some of the challenges and possible approaches for forecasting urban water demand are presented in a July 2003 report titled “Water Demand Forecast Methodology for California Planning Areas: Work Plan and Model Review”. (See Technical Guide.) The authors of the report offer recommendations for:

- near-term analyses given available data, and
- future development for long-term analyses.

The recommendations for future development identify additional data needs such as:

- water and sewer rate data for the utilities and time frames for data contained in DWR’s Public Water Supply Survey database
- correlate local and regional demographic information with per unit water use rates by area
- correlate climate conditions with per unit use rates over time

This new information will allow DWR to update their statistical explanatory demand models by region based on some of these key factors. DWR will have to examine other factors and determine the best way to quantify those factors. DWR expects that other data gaps will emerge leading to better understanding of the type of data collection and analysis needed to support the new planning framework.
Alternative Response Packages

A significant difference in the new water plan framework will be the addition of quantitative comparisons for alternative response packages of water resource management strategies, which are described in Volume 2. This performance comparison of various mixes of water management strategies under plausible future scenarios will provide planners unprecedented access to relevant technical information and new insights. This quantitative insight can be used to help guide investments in statewide water management actions. To help focus the quantitative analyses, a list of evaluation criteria have been identified with the advisory committee and Analytical Tools and Data Work Group that represents the technical information required to compare the response packages. A full list of the evaluation criteria are included in the Technical Guide. These evaluation criteria include information such as:

- percent of years agriculture receives all of its desired water supply
- economic benefits or losses
- statistical water supply reliability by location
- regional imports and exports
- water quality
- instream flows

While this information is expected to be extremely valuable, developing the capability to complete these performance comparisons presents a significant challenge for DWR over the next several years. Conducting quantitative performance comparisons that water managers, decision-makers, and the public want will require considerable staff, time, and money to develop and implement.

Analytical Tools

Generating quantitative estimates for most of the information contained in the water portfolios, future scenarios, and comparing performance of strategies requires the use of one or more analytical tools. The term analytical tool is defined to mean something used to study or determine the nature and relationship of the component parts of a whole. Given the broad range and scale of quantitative information desired, many analytical tools will be needed. No single analytical tool could be developed to provide all of the desired information, but rather a hierarchy of tools must be employed.

The role of an analytical tool and the method for using it varies significantly depending on the specifics of the information being generated. Given the desire to promote understanding and transparency of analysis, the update team will apply a systematic method to identify potential analytical tools, determine their proper use, and validate their application to generate all of the quantitative information needed for the water plan.

Initially, this effort will focus heavily on the need, availability, and adequacy of technical tools to perform the integrated analyses. Given the high degree of interest expressed by several members of the advisory committee and the Analytical Tools and Data Work Group, DWR proposes a systematic, step-by-step approach to develop acceptable methods to complete the quantitative analyses for both the short-term – the next update – and long-term efforts -- 10-15 years. This step-by-step approach is outlined below, and will require extensive participation from the Analytical Tools and Data Work Group.
Once the methods have been defined and agreed upon, DWR will need to set up and conduct the analytical studies, perform quality control reviews of study results, and interpret and communicate the meanings of the analytical tool outputs.

Framework to Assess an Analytical Tool

Evaluating the appropriateness of an analytical tool to produce quantitative estimates can be extremely complicated. To help make the process as effective and transparent as possible, the team will apply the following framework, described using a series of questions, for each item on the comprehensive list of technical information needs.

- What is the job at hand?
  - Describe by task if needed, highlighting the quantitative results that would assist in accomplishing the task.
- If the ideal tool to assist with the task were available, what capabilities would it have?
- Which tools are available that could produce the desired quantitative results?
- Which tool or tools represents the best fit for the specific information desired?
  - Evaluate the potential tools according to the desired capabilities.
  - Consider limitations.
  - Consider practical ability to improve each tool.
- What are the remaining limitations of the selected tool likely to be?

This process can be improved by using common, objective evaluation criteria to the extent possible for each piece of technical information being generated. The criteria used to answer the question “Which tool or tools currently represent the best fit?” will be discussed and documented before making any judgments about the suitability of the analytical tools in question.

Parts of an Analytical Tool

To understand the capabilities of an analytical tool, or to assess the validity of using an analytical tool for a specific purpose, it is helpful to consider the tool in terms of its parts:

- Conceptual model: a description or analogy used to visualize something that cannot be observed directly, such as a road map of a large area.
- Theoretical model: a system of postulates, data, and inferences presented as a description of an entity or state of affairs, such as the law of gravity.
- Numerical model: an analytical tool that employs quantitative approximations to the solutions of mathematical problems.
- Data
- Data management system
- Software
- Administrative aspects: intellectual property (proprietary vs. public domain), user support, expertise available in community to use or improve model, etc.

Describing an analytical tool using these categories promotes more precise discussions regarding the capabilities and appropriate use of analytical tools.
Information Management System

The quantitative elements of the water plan require tremendous amounts of data and information. As such, effective management of this information is a key component to the long-term success of the technical efforts. Currently available information management system technologies could be used to provide efficient, secure, and transparent access to this critical component of the ongoing state wide planning efforts.

However, the technology alone is not sufficient. A necessary part of a successful information management system is an intelligent information management framework and scheme. Ideas for a viable information management framework can be developed as the needed data, relationships, and estimates for the quantitative analyses are further described.

Resources Needed

DWR is committed to leading the way in developing the methods, analytical tools, and conducting the analyses to provide the information California needs in a transparent and responsive manner. Generating and interpreting the quantitative information described above will require persistent dedication of significant resources. The technical scope and magnitude of the desired analyses is unprecedented in California water planning. While several parts of the desired analyses have been done before, no previous quantitative study has ever been conducted so comprehensively and with such intensive stakeholder interaction. Needless to say, a team of technical experts with diverse skills will need to be engaged over a significant period of time. Technical experts will be needed who can understand the complex interaction between policy-making and technical analyses, organize technical information needs, identify and qualify subject-matter data, manage extensive data, interface with diverse stakeholders and programs like the California Bay Delta Authority, and demonstrate leadership to inspire confidence and credibility within policy and technical communities.

Major Tasks and Schedule

The following tasks and associated schedule outline the major steps DWR plans to take to provide the desired technical information in a timely manner. As shown in the schedule, DWR plans to perform these activities with frequent and detailed interactions with interested parties through the Analytical Tools and Data Work Group. This framework requires that DWR receive assistance from others to complete the tasks. The rate of progress will depend on available resources and the level of cooperative and active participation by other agencies and institutions. This systematic approach will allow DWR and others to address concerns raised about validity of existing tools and questions raised about the appropriateness of quantitative methods used for previous technical studies.

1. Generate a priority list of quantitative information needed to provide results for the evaluation criteria
2. Propose a conceptual model or models for each evaluation criteria, such as urban water supply reliability, detailing the observable data and causal relationships as they relate to:
   a. Water portfolios
   b. Future scenarios for 2030
   c. Alternative response packages

These conceptual models will be developed sequentially by focusing on one evaluation criterion at a time. This effort will take advantage of the current scientific information available for each topic.
3. Distribute documents containing the proposed conceptual models to the Analytical Tools and Data Work Group (and other recognized experts according to the topic being discussed) and conduct workshops to revise and adopt preferred conceptual models that will be used to compute results for each evaluation criteria.

4. Once conceptual models are adopted, propose a theoretical model for each piece of required quantitative information including: postulates, data, and inferences.

5. Distribute documents containing the proposed theoretical models to the Analytical Tools and Data Work Group and conduct workshops to adopt preferred theoretical models used to compute each piece of quantitative information.

6. Establish, to the extent possible, objective criteria for evaluating the suitability of potential analytical tools for generating each piece of desired quantitative information.

7. Compare preferred theoretical models with those implemented in currently available analytical tools.
   a. Review existing analytical tools to determine if they incorporate some or all of the preferred theoretical models.
   b. As needed, determine if existing analytical tools can be modified for short-term use

8. Modify tools as needed and as possible for short-term use.
   a. Make changes to existing analytical tools to better incorporate preferred theoretical model implementation that can be accomplished by the end of 2006.
   b. Acknowledge and document where existing tools and data that will be used for the next Water Plan update fall short of the desired theoretical implementation and cannot be suitably modified by end of 2006.
   c. Prepare a document that describes how analyses for the next Water Plan update will be implemented in the short-term.

9. Develop a document that outlines requirements for new analytical tools and data to perform the preferred quantitative analyses for future updates in cooperation with the California Water and Environment Modeling Forum long-term strategic framework.
   a. Describe likely approach to obtain or develop tools that can fulfill the requirements.
   b. Develop a schedule for development and testing.
   c. Develop budget for development and testing.

10. Apply existing analytical tools to quantify all required quantitative information about future conditions for next Water Plan update by the end of 2008.
    a. Future scenarios
    b. Alternative response packages

11. Interpret and describe quantitative results for
    a. Future scenarios
    b. Alternative response packages

The Next Water Plan Update and Beyond

The tasks described above are focused towards identifying and developing trusted and acceptable quantitative methods over the next three years that can be applied as completely as possible in the short-term for the next Water Plan update, and as close to the preferred methods as possible for updates beyond the next one. As these requirements, data gaps, and preferred conceptual and theoretical models are adopted, DWR will also identify the requirements for a viable information management system. Given the magnitude and complexity of information, and the desire to coordinate and share this information at various levels of detail throughout the state, DWR likely will need to implement an enterprise-level information management system accessible via the World Wide Web.
Furthermore, as progress is made in developing better, more comprehensive data and analytical tools to analyze the water movement and interactions, DWR intends to foster development of decision support tools that increase planners’ ability to fully utilize the new and improved technical information being provided in future updates.
Improving Analytical Procedures Used to Describe Future Water Conditions for the California Water Plan

By Ken Kirby, SKS Consultants
Improving Analytical Procedures Used to Describe Future Water Conditions for the California Water Plan

By Ken Kirby, SKS Consultants

A major change in California Water Plan, Bulletin 160-05, is the departure from the analytical procedures used in previous water plans to describe future water conditions for California. Because of the limitations discussed below, the continued application of prior analytical procedures to describe future water conditions was commonly seen by Water Plan Advisory Committee members to have limited conceptual and practical value for planning and policy, and at worst had the potential to lead decision makers in the wrong direction in their water planning and policy-making. While the new plan has departed from this traditional analysis, it has not yet been replaced with a more comprehensive approach backed by stakeholder consensus. Here, we review the analytical procedures used in the previous Water Plan, Bulletin 160-98, and discuss where improvements need to occur. This paper builds on a related, unpublished opinion paper by Dr. Jay Lund of UC Davis and Dr. Robert Wilkinson of UC Santa Barbara entitled, “Mind the Gap: Traditional versus Modern Supply and Demand Analysis for California Water”, dated June 14, 2005.

What was Done in Previous Water Plans?
Previous California Water Plans compared projected average year water uses to projected average year water supplies to estimate a shortage or surplus, so-called “gaps”, statewide and by region. This general approach has appeared in State water plans of 1930 and 1957 through 1998, with the addition of “drought” years appearing in the 1993 and 1998 plans.

In Bulletin 160-98, estimates were made of current level and future level water uses and supplies, with the difference shown as a gap. Then, possible future water management options were compared to initial screening criteria to identify those water management options suitable for further evaluation. This analysis was performed for two water supply scenarios – typical average year and drought year, for both current conditions and future conditions. Water budgets were presented as a statewide summary and a summary for each of the state’s 10 hydrologic regions. By necessity these summaries simplified what was happening at the local scale. However, the actual analysis was performed at a much smaller geographic scale. The major steps in the Bulletin 160-98 planning process are summarized in the box.

### Summary of the Bulletin 160-98 Water Management Options Evaluation Process
- Identify water demands and existing water supplies on a regional basis.
- Compile lists of regional and statewide water management options.
- Use initial evaluation criteria to either retain or defer options from further evaluation. For options retained for further evaluation, group some by categories and evaluate others individually.
- Identify characteristics of options or option categories, including costs, potential demand reduction or supply augmentation, environmental considerations, and significant institutional issues.
- Evaluate each regional option or category of options in light of identified regional characteristics using criteria established for this Bulletin. If local agencies have performed their own evaluation, review and compare their evaluation criteria with those used for the Bulletin.
- Evaluate statewide water management options.
- Develop tabulation of likely regional water management options.
- Develop a statewide options evaluation by integrating the regional results.
Areas Where Current Analytical Capabilities Need to be Improved

Several factors have caused DWR to rethink how it evaluates California’s future water conditions. First, there is a need to provide policy-makers and the public with more detailed quantitative information about the costs, benefits, and broad social, environmental, and economic tradeoffs associated with different water management strategies. Second, data, analytical tool development, and data management have not kept pace with growing public awareness of the complex interactions among water-related resources. Finally, California lacks a consistent framework and standards for collecting, managing, and providing access to data and information on water and environmental resources essential for integrated resource planning. More accurate data and analytical tools and better information management can reduce many uncertainties about the state’s current and future water resources: how water supplies, demands, and quality change in response to different resource management strategies; how ecosystem health and restoration can succeed; and how we can adapt our water system to reduce controversy and conflicts.

Any evaluation of future water supply and demand conditions requires more robust data, estimation methods, and analytical tools. The use of estimation methods and analytical tools is unavoidable because data for the future is largely unavailable. Stakeholders have raised concerns about estimates, estimation methods, transparency, and documentation procedures used for past Water Plan Updates. However, these concerns are not unique to the Water Plan. In fact, there are no existing tools that address these problems sufficiently to be used for the Water Plan without significant modification. The following are some of the specific limitations identified by the Water Plan Advisory Committee and Water Plan staff related to analysis performed in Bulletin 160-98.

Data. The Water Plan is statewide in scope. Much of the basic water supply and demand data are limited in availability, quality, transparency, and documentation. An example is groundwater data, where there is insufficient data available statewide and insufficient staff resources to conduct a comprehensive assessment of future groundwater conditions. Bulletin 160-98 responded to this by estimating groundwater use based on land use, unit water use and supply source. However, this approach prevents a full description of future groundwater storage conditions, groundwater recharge, and the connection to surface water.

Water Flow and Operations Models. Commonly, computer models are needed to estimate how water will be stored and allocated to produce water deliveries or supplies to various areas over a range of projected conditions. However, currently available operations models do not capture the complexity of the water management system to study questions raised by decision makers and stakeholders. For example the CALSIM II model underwent a significant stakeholder review in 2003 through the California Bay-Delta Authority Science Program. The review affirmed CALSIM’s use of an optimization engine for hydrology simulation and allocation decisions, the model’s numerous recent improvements, and successes addressing many of the complexities of the SWP and CVP systems and water management decisions. The review also identified many areas of needed improvement including determination of local water supplies, description of the groundwater system, and the geographic scope. Stakeholder uncertainty about
the operations models used to generate information for the Water Plan added to the uncertainty and controversy of Bulletin 160-98 water supply and water use projections.

**Forecasts of Future Water Uses.** Future water use can be estimated by employing computer models. While Bulletin 160-98 used a state of the art water use forecasting model (Water Savings Simulation Program), the Bulletin failed to adequately communicate the details of the model and how it was applied. More sophisticated models of water demand like IWR-MAIN have yet to be applied on a statewide scale and must be proven to provide the kind of transparent, documented, and tested methods desirable for a more open planning analysis of water in California.

**Scenarios.** Different assumptions about the future can significantly affect the nature and outcome of various mixes of management strategies. Some management strategies may be effective and economical for a wide range of scenarios. Other strategies may be more suited if specific conditions develop in the future. Bulletin 160-98 examined a single “likely” future for two supply scenarios (average and drought conditions). Multiple scenarios of baseline conditions offer water planners, decision makers, and stakeholder’s new insight into the key assumptions related to water supply and demand and reveal opportunities to make critical management changes.

**Consumptive and Non Consumptive Water Uses.** The concepts of consumptive water use and non consumptive water use are critical to understanding the movement of water in the system. Consumptive demands include activities that deplete water from the water management system by evaporation, evapotranspiration, or flows to saline water bodies. Non-consumptive demands include activities that require a specific quantity of water at a particular location and time, but do not deplete water from the water management system. This includes releasing water for hydropower production, instream flows, or the portion of municipal water use that flows to a wastewater treatment facility and is later released to a stream or recharged to groundwater. While the Bulletin 160-98 analysis did explicitly account for both consumptive and non-consumptive water uses, this information was not presented in a way that was easy to understand.

**Economic Efficiency.** The role of economics in forecasting water use and evaluating management options is becoming a larger part of water planning. A gap between a supply and forecasted use does not mean that more water is “required” to fill the entire gap because economic efficiency should still be considered. Considering economic efficiency means that the economic benefits received by reducing the scarcity of water should be compared to the costs before implementing new water management strategies. Improved methods for implementing a more strategic view of water management planning now exist and should be used. These new methods improve the determination of the effects of economic factors on water use, the evaluation of the scarcity value of water, and the evaluation of the economic justification of specific water management options. Bulletin 160-98 did use some economic concepts related to agricultural markets and population and urban income growth in water use forecasts, but the economic assumptions were not transparent, the economic efficiency criterion was not specifically applied, and the economic analysis was not done as comprehensively as some stakeholders wanted.
Hydrologic Variability. California’s size, ocean influence, and varied geography result in a varied climate, which adds to the difficulties of predicting future hydrologic conditions. Water availability and use vary significantly over a wide range of wet to dry years, including persistent series of wet and dry years. The presentation of a water balance for single “average” and “drought” years in Bulletin 160-98 did not provide enough details on many important water management activities that store water in wet years (or wet seasons) for use in dry years (or dry seasons), and the frequencies of surplus or shortage quantities. A wide range of wet and dry events is important for planning and policy, helping us identify particularly worrisome conditions and promising opportunities.

Water Quality. Bulletin 160-98 had limited representation of problems and opportunities regarding water quality. Many water operations today are driven by water quality objectives. Improvements are needed in procedures to integrate water quality with water quantity. Limited availability of water quality data is a significant obstacle to implementing this goal.

Single-objective. Bulletin 160-98 summarized the performance of the water system with respect to only an average year and drought year water supply objective. While this might have once been sufficient, California’s water management objectives are now much more diverse, complex, and inter-twined. Many objectives were considered in the Bulletin 160-98 planning process when screening potential water management options. These included potential negative effects or barriers associated with engineering limitations, economic factors, the environment, institutional or legal factors, social and third party considerations, and human health. However, these objectives were evaluated outside of the analytical procedures used to estimate future water use and supply. A major challenge is to integrate water management objectives with the water use and supply analysis in a transparent and robust way to better evaluate the costs, benefits, and tradeoffs associated with competing water management options.

Groundwater Management. Some parts of California have persistent overdraft of groundwater. In the short-term, such overdraft is used as a supply. In the long-run, such overdraft can lead to water quality degradation, land subsidence, increased pumping costs on water suppliers, and other problems. The analytical procedures applied in Bulletin 160-98 did not lend itself to adequately evaluate and describe groundwater management in California including the effects of groundwater overdraft and the ability to integrate groundwater and surface water management for multiple objectives. The limited availability of groundwater information is a major barrier to implementing a more integrated analysis.

Transparency and Level of Detail. As stated earlier, Bulletin 160-98 presented water balances as a statewide summary and a summary for each of the state’s 10 hydrologic regions. By necessity these summaries simplify what is happening at the local scale. Unfortunately these simplified summaries of average year supplies and demands has led to the perception that there are straightforward solutions to California’s water problems. The lack of regional details about water uses, supplies, and water management strategies also tend to mask the reality, complexity, problems, and opportunities for water planning and policy in California, particularly from the perspective of a local water agency.
What should come next?

There is considerable agreement that California needs some sort of quantitative analysis of future water use and supply conditions. However, there is little consensus as to the precise form this analysis should take. DWR is working to reach consensus with the Water Plan Advisory Committee on an improved analytical approach in forthcoming water plans. Several efforts to improve analytical capabilities for statewide water planning are being undertaken, notably by the California Water Plan, the CALFED Surface Storage program, and the California Water and Environmental Modeling Forum (cwemf.org). And several major water suppliers in California already employ sophisticated and insightful forms of water supply and demand analysis, notably Metropolitan Water District of Southern California and San Diego Water Authority. This is a difficult transition in Water Plan analysis, from projected, average year water uses and projected average year water supplies, to an approach showing robust, diversified, and cost-effective portfolios of local, regional, and statewide water management activities for multiple objectives over a range of hydrologic and future conditions.

DWR outlined some initial directions for improving analytical procedures in Chapter 4, Volume 1 of Bulletin 160-05. This included a partial application of an approach to implement multiple scenarios of future baseline conditions in the Water Plan. The information in Chapter 4 is further elaborated on in several Bulletin 160-05 Reference Guide articles (Volume 4) in the section, “Data and Analytical Tools”. DWR is also collaborating with others to investigate new, cutting edge approaches to water planning. Some immediate next steps for DWR are described in a concept paper, “Recommended Next Steps for Improving Quantitative Information for the California Water Plan”. This concept paper (also in Volume 4) will be used to start discussions with other planning entities, decision makers, and stakeholders to develop a long-term approach for improving analytical procedures used for statewide water planning.
Recommended Next Steps for Improving Quantitative Information for the California Water Plan
Recommended Next Steps for Improving Quantitative Information for the California Water Plan
October 11, 2005

Abstract
This proposal identifies three broad activities that must be initiated and conducted simultaneously to improve the analytical capabilities of the California Water Plan. These are:

- Promoting Collaboration
- Facilitating Information Exchange
- Improving Numbers for the California Water Plan

California needs significant improvements in its analytical tools and data to effectively evaluate the costs, benefits, and tradeoffs of alternative water management strategies. These improvements must be done in a way that promotes regional integrated resource planning. Recent water bonds, the California Water Plan, and CALFED Bay-Delta Program have all highlighted the need for greater emphasis on regional decision making in water planning.

There is a tremendous amount of work to be done to provide the desired quantitative deliverables for future Water Plan Updates. This work needs to be done during a time of limited budgets and considerable uncertainty with institutional responsibilities related to the CALFED Program. Recent events have placed much more attention on this matter than is typical within the public policy arena. We have an opportunity to take advantage of this increased attention and bring people together and encourage creativity about how the information that people are asking for can be provided with transparency.

It is important for DWR to build momentum in the quantitative activities described in this proposal. And it is important that key policy advocates are aware of the need to improve statewide water planning and how they can help to set realistic goals as we proceed.
Background

Several factors have caused DWR to rethink how it evaluates California’s future water conditions. First, there is a need to provide policymakers and the public with more detailed quantitative information about the costs, benefits, and tradeoffs associated with different water management strategies. Second, data, analytical tool development, and data management have not kept pace with growing public awareness of the complex interactions among water-related resources. Additionally, California lacks a consistent framework and standards for collecting, managing, and providing access to data and information on water and environmental resources essential for integrated resource planning. More accurate data and analytical tools and better information management can reduce many uncertainties about the state’s current and future water resources: how water supplies, demands, and quality change in response to different resource management strategies; how ecosystem health and restoration can succeed; and how we can adapt our water system to reduce controversy and conflicts.

Organizing a Response

DWR, through the California Water Plan, proposes to take the lead in organizing a response to the limitations described above. With assistance from Dr. Kenneth Kirby of Active Curiosity Inc., DWR has identified three broad activities that must be initiated and conducted simultaneously to improve analytical capabilities in support of the Water Plan. The context and next steps for implementing the three activities described below are the focus of this proposal. Implementing a response requires significant participation by many entities who either generate information used by the Water Plan or use information in the Water Plan to make decisions. The critical activities are:
- Promoting Collaboration
- Facilitating Information Exchange
- Improving Numbers for the California Water Plan

Promoting Collaboration

There are many reasons to promote collaboration. Integrated resource planning requires multidisciplinary information, and no single entity has the expertise or other resources required to develop all of the analytical tools and data needed to answer these broad questions. Furthermore, people want to improve the shared understanding and access to useful information across the state at an appropriate resolution. This desire to report information at various resolutions around the state requires that local and regional entities be able to interact and share data in some commensurate way. Promoting collaboration includes improving the institutional setting for quantitative work and partnering on near-term studies.

Improving the Institutional Setting for Quantitative Work

Perhaps one of the most critical activities for the near future will be to engage interested parties throughout the state to establish a new institutional network to leverage available resources and improve the shared quantitative capability involving California’s water management system. As discussed in the background section of this document, existing analytical tools are not sufficient to meet all of today’s needs for quantitative information. Effectively meeting these needs will require considerable networking, collaboration, and information sharing between federal, state,
local, and regional entities. The September 2005 report prepared by the California Water and Environmental Modeling Forum (CWEMF) titled, “Strategic Analysis Framework for Managing Water in California”, presents a wide array of possible institutional arrangements that could improve the institutional setting for developing and applying qualitative capability over the long-term.

Next Steps for DWR:

- DWR will take the lead to form a broader institutional network dedicated to the development and proper application of quantitative capability for water management needs throughout California. DWR will invite and encourage others to join this network.

- DWR will seek advice from the Water Plan Analytical Tools and Data Workgroup about how best to implement the work described in this paper and how best to interface with activities conducted by CWEMF.

Partnering on Near-Term Studies

For preparing California Water Plan Update 2005, DWR established some mutually beneficial partnerships with entities engaged in research or studies of interest to the Water Plan. DWR will continue to form these partnerships for the next Water Plan Update as a way of infusing new ideas and to maximize the benefit of outside expertise and funding. At this early stage, DWR has engaged in two promising partnerships:

1) DWR is working with the Rand Corporation to evaluate uncertainty in water management using the technique of Robust Decision Making.

2) DWR is working with the Natural Heritage Institute, the National Center for Atmospheric Research, and the Tellus Institute to evaluate the effects of climate change on water management in California using the Water Evaluation and Planning System model, WEAP.

Next Steps for DWR:

- In collaboration with others, DWR submitted several proposals through the 2004 CALFED Science Proposal Solicitation Program that could serve as additional areas of investigation. Although these projects were not recommended for funding they can form the basis for future research. These proposals would develop decision support tools, improve linkages between existing models, improve the Integrated Groundwater Surface Water Model (IGSM2), and provide better estimates of evapotranspiration from agricultural lands and managed wetlands.

- DWR will work with the Analytical Tools and Data Workgroup to identify areas of key research interest for the next Water Plan update. DWR will seek out entities engaged in these key research areas and invite them to collaborate on mutually beneficial projects. DWR will pursue those projects where each side is willing and able to dedicate the required resources to implement the project.

- DWR’s Water Plan and CALSIM III development staff are working to improve communication between DWR’s data collection activities and its analytical capabilities.
DWR is exploring the possibility of contracting with the University of California, Davis, to apply the CALVIN model to develop and evaluate response packages to the scenarios described Water Plan Update 2005.

**Facilitating Information Exchange**

In the *California Water Plan Update 2005*, DWR committed to begin implementing “… the Water Plan Information Exchange (Water PIE) for collecting and sharing data, and networking existing databases and websites, using GIS software to improve analytical capabilities and developing timely surveys of statewide land use, water use, and estimates of future implementation of resource management strategies”. Implementing Water PIE requires both short-term and long-term phases. The short-term phase will likely include showing linkages and providing easy access to information used by the CALFED Bay-Delta Program Common Assumptions and California Water Plan to assess current and future water management conditions. This will help to promote transparency and build confidence among stakeholders that related statewide planning efforts are being sufficiently coordinated. The goal of the long-term phase is to develop an interactive data management system to promote integrated regional water planning. Water PIE will require protocols for managing data including a common definition of terms and data quality control. Promising next steps for Information Exchange follow.

**Next Steps for DWR:**

- DWR will work with the Water Plan Analytical Tools and Data Workgroup to develop a strategy to exchange information. Key tasks for information exchange include developing a common glossary of terms, water budget components, and guidelines for data collection, compilation, and management.

- DWR will meet with other agencies responsible for implementing data sharing programs to learn about the approaches used and challenges faced. Examples include MWD’s Integrated Water Resource Plan, The Santa Ana Integrated Watershed Plan, the California Environmental Data Exchange Network, and the California Data Exchange Center.

- DWR will develop a Web portal to link to or publish data used by the California Water Plan and the CALFED Bay-Delta Program Common Assumptions group. The initial focus will be on agriculture water use efficiency, urban water use efficiency, conjunctive management, water recycling, desalination, and water transfers. Information sources may include:
  - State water bond grant proposals
  - Agricultural Water Management Plans
  - 2005 update of Urban Water Management Plans
  - DWR’s California Land and Water Use database and web portal
  - California Water Plan Water Portfolios
  - Later efforts may include information from City and County General Plans.
Improving Numbers for the California Water Plan

The CWP Update 2005 outlines three sets of quantitative deliverables:

- Water Portfolios
- Future Scenarios
- Alternative Response Packages

The information provided from these quantitative deliverables will be in the form of reporting metrics. Reporting metrics are quantitative numbers that represent something measurable. These numbers are reported prior to a judgment of the adequacy or desirability of the numbers with respect to specific objectives.

With regards to providing these quantitative deliverables in future Water Plan updates, the following activities were contained in the Update 2005 action plan:

- Develop a general checklist of issues, resources, data, and analytical tools as well as guidelines to aid regional integrated resource planning.
- Select and/or develop analytical tools and data in support of the next California Water Plan Update.
- Participate in efforts by the CWEMF to develop and carry out a plan for long-term improvement of analytical tools and data for statewide water planning.

A significant barrier to reaching agreement about specific computational methods is an insufficiently developed shared understanding of how the California water management system works, and how it responds to changes. When there is a technical disagreement about a model or parts of a model, we rarely have a productive discussion that leads to resolution. Discussions tend to be vague. The only approach effectively applied to resolve technical disputes has been to pay experts to conduct a scientific review. This is both expensive and slow. It would be much better to have a process for simultaneously improving the conceptual understanding of California’s water management system and its representation in the analytical tools we use. To achieve this end the CWP team has committed to:

- Take a fresh look at our collective understanding of how the water management system works
- Interact with experts to make sure we capture the latest thinking
- Document our collective understanding of the water management system in an archival manner that can evolve over time

These ideas were presented and discussed in a meeting with the Analytical Tools and Data Workgroup on June 3, 2005. The major concepts are outlined in a PowerPoint presentation used during that meeting (see http://www.waterplan.water.ca.gov/tools/index.cfm). During the meeting, DWR proposed to apply a standard analysis and design approach used widely in the software development industry, called the Unified Process. The Unified Process is an iterative approach based on object-oriented thinking that allows a team to identify and describe the relevant aspects of the real world that should be represented in an analytical tool to fulfill a particular purpose. Through the Unified Process, a number of artifacts can be developed collaboratively to document the requirements of the quantitative analysis system, and a shared understanding of the water management system. The artifacts can be developed using the Unified Modeling Language (UML), which is a visual notation language that provides a standard...
notation to describe a system in terms of objects, relationships, interactions, sequence diagrams, and state changes. We propose to proceed with this or a similar method by focusing on one reporting metric at a time (e.g., urban water demand) so that the discussions can be specific.

Next Steps for DWR:

- DWR will raise awareness and provide training for DWR staff and interested stakeholders in the areas of object-oriented thinking, the Rational Unified Process, and the Unified Modeling Language. An initial one-day workshop will be held for program managers to provide an overview of these ideas. CWP will work with our stakeholders on how to use UML or other identified approaches for documenting the important factors and interrelationships that describe the water management system.

- DWR will work with the Analytical Tools and Data Workgroup to create a “high-level” conceptual design that describes urban water demand. This conceptual design will identify the components of the water management system necessary to compute urban water demand under various conditions. Examples of these components include demand forecasting, supply forecasting, and technology adoption. These component descriptions will be created and refined over time.
A Strategic Analysis Framework for Managing Water in California
By California Water and Environmental Modeling Forum
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for
Managing Water in California

Final Report 2005-1

September 2005

California Water and Environmental Modeling Forum
Ad hoc Committee on Long-Term Model and Data Development
A Strategic Analysis Framework for Managing Water in California

Summary

Today’s water management problems differ significantly from those of the past. To solve today’s problems, new analytical perspectives are needed to serve more contemporary and decentralized decision-making processes. The success of California’s complex water system depends on how well the water community develops and uses data and models to address water management problems. Development of water-related databases and models must be undertaken with explicit involvement from local, regional, and statewide interests and diverse expertise. It must be transparent and subject to stringent quality control. This report advocates a broadly based, broadly supported, and comprehensive approach to this problem.

Current and emerging water management problems require more sophisticated models. For example:

a) **State and Federal Investments**: What can a specific water management investment achieve for environmental, urban, and agricultural purposes under different scenarios?

b) **Urban Water Supply Reliability**: What is the best approach to secure a reliable water supply to meet urban needs and promote economic growth, consistent with environmental protection and agricultural prosperity?

c) **Agricultural Water Security**: How can agricultural water supply be managed to allow farms to remain productive and profitable while protecting the environment and urban prosperity?

d) **Environmental Restoration**: How can California use water most effectively for environmental purposes while protecting agricultural and urban prosperity?

e) **Climate Change**: How should local, regional, and statewide water managers plan for likely changes in demand and hydrology due to changing climate?

f) **Floods**: What strategy for flood management should California adopt given floodplain urbanization, climate change, multiple demands on reservoirs, and limitations in flood forecasting?

g) **Water Right, Contract, Transfer, and Regulatory Accounting**: How much water can a particular water right or water contract provide under different scenarios and regulations? How feasible are complex water transfer options?

The California water community is asking these questions in an increasingly decentralized decision-making environment with interacting local, regional, and statewide management alternatives. This decentralized situation differs fundamentally from the centralized and isolated development of data and models in the past. To provide reliable and well-documented technical analyses, California needs to develop a coherent set of databases and models that meets the following criteria:

- **Strategy** – Data, models and communications tools should be developed and integrated as part of a broadly-based strategic effort focusing on likely future water problems in California. This strategy should be documented, updated, and coordinated with major modeling and stakeholder groups.
• **Transparency** – Data and models should be documented in a self-critical way so limitations are better known and considered. Documentation should be available to public scrutiny.

• **Technical Sustainability** – Data and model development are long-term efforts that must incorporate advances in scientific knowledge and the water communities’ understanding of water problems as they become available. Models and data should be developed in a strategic modular way.

• **Coverage** – Water management in California involves not only statewide activities and processes, but also local and regional activities and processes. Consequently, California needs a statewide concerted effort to integrate the problems, resources, opportunities, and expertise available at the local and regional levels.

• **Accountability and Quality Control** – To improve the quality and transparency of model applications, models must be ground-truthed with the help of local experts. Protocols for model use and documentation, including limitations, must be developed.

The development of such databases, models, and communications tools will require a concerted, long-term effort and a broadly based strategic analysis framework for water problems in California. The major components for a framework are:

• Purpose and objectives
• Data review and management
• Models and communication tools
• Principles for data and model development
• Institutional and financial support

The development and implementation of a strategic analysis framework will require considerable time, resources, and dedication, and will complement ongoing policy and modeling efforts that address immediate needs. To begin this process, the California Water and Environmental Modeling Forum proposes the following immediate activities:

1) **Purposes and Objectives**
   Through a collaborative process with key responsible agencies, identify, review and revise, if necessary, the Strategic Analytical Framework’s long-term purpose and objectives.

2) **Data Review and Management**
   a) Critically review the achievements and lessons of data development efforts both within and outside of California.
   b) Critically review existing databases in California and assess uncertainties in these data.

3) **Modular Models and Communication Tools**
   a) Critically review development efforts both within and outside of California.
   b) Revise and update the 2000 Modeling Forum report *Modeling Protocols for Water and Environmental Modeling* to provide more specific technical and procedural guidance consistent with the principles identified in this report.

4) **Institutional and Financial Support**
   Continue discussion with agencies to establish an institutional and funding basis for developing and implementing a strategic analysis framework for water management in California. This is the single most important activity in the immediate term since the success of the entire effort depends on it.
PREFACE

At its 2004 annual meeting, the California Water and Environmental Modeling Forum (Modeling Forum) initiated a discussion on the need for a comprehensive strategic analysis framework to guide the development of databases and models for managing water in California. An ad hoc committee on long-term modeling and data development was formed and embarked on an effort to identify (1) the key issues that the California water community will need to address in the next ten years and (2) the types of database and models needed to support future water policy, planning, and operation decisions. The committee solicited input from California water professionals through (1) a questionnaire consisting of four open-ended questions, (2) two half-day technical workshops conducted in the summer of 2004, (3) a plenary session at the Modeling Forum’s 2005 annual meeting, and (4) comments received through other forums.

This report discusses the results from these efforts and proposes the development of a strategic framework for water management in California. This framework will guide the development of databases and models to provide reliable quantitative information under a broad range of scenarios. The framework is broad-based and involves agencies and expertise from all levels. It is technically focused and designed to support a variety of policy, planning, and management applications. A complete, integrated quantitative description of all aspects of California’s water system is an ambitious goal, and broad stakeholder support for the framework is necessary to begin serious progress.

The Modeling Forum’s Steering Committee accepted this report at its September 2005 regular meeting. However, this report does not necessarily represent the views of the member agencies or individual members of the Modeling Forum.

The Steering Committee thanks the many colleagues who contributed to this report through their participation in workshops, responses to surveys, and discussions. Many of their ideas are incorporated throughout this report. The Modeling Forum plans to continue this dialog with stakeholders and welcomes input and further discussions with interested parties.
I. INTRODUCTION

The long-term success of California’s complex water system depends on how well the California water community collects, manages, and uses data and models to support operations, planning, and policy development. Recognizing this need, the California Water and Environmental Modeling Forum (Modeling Forum) promoted discussions on how to improve information and analysis for water management and decision-making. The result of this effort is a proposed Strategic Analytical Framework for the long-term development of data and models to manage water in California. While the results of this work might be useful for current planning and policy deliberations, it is specifically focused on a ten-year or more horizon. This allows the Strategic Analytical Framework to (1) focus on the technical environment of greatest long-term value, (2) avoid too much emphasis on current (but sometimes transient) problems, and (3) avoid confining the water community to existing data and models.

This Strategic Analytical Framework is intended as a basis for further discussion and action. While it cannot address the entire list of long-term water problems that California may face, its fundamental principles can be applied, extended, and modified to aid in understanding and managing the wide variety of evolving California water problems.

This report is organized as follows: Section I is the Introduction. Section II discusses recent developments in California water management that increase the role of technical analysis in management decisions. Section III summarizes key management issues that pose specific long-term challenges to technical analyses. It also defines the modeling requirements for adequate and reliable analyses of these issues. Section IV summarizes key requirements for a strategic framework. Section V discusses the initial steps towards the development of a framework. In particular, it proposes pilot projects that could proceed with modest resources. Appendices A through E provide additional background information.

II. PROBLEM SETTING

In recent decades, California’s water problems have evolved substantially because of greater and more diverse demands on California’s water system, increasing operational complexity of the system, increasing roles of local and regional agencies, and higher expectations of technical analyses.

- The technical complexity of California water management is increasing. Technical aspects of water policy, planning, and operations have become much more complex. For example, water quality requirements, which add a new dimension to management decisions, have become more demanding, especially for drinking water uses. Increasing and diversifying demands and regulatory complexity have led water managers to explore and adopt new water management options in addition to the traditional water storage and conveyance facilities, such as:
  - conjunctive use of surface and ground water
  - coordinated operation of reservoirs and pumping facilities of different projects
  - water markets (including long-and short-term options, transfers, and exchanges); and
  - wastewater reuse
improvements in water use efficiency

Effective water system management requires careful coordination of such new options with traditional water management strategies.

- **Institutional aspects of California water management have become more complex.** Water management initiatives are no longer limited to the state and federal levels. Local and regional leadership and financing are increasing. Operations of this myriad of water projects affect each other, and they must be coordinated to meet environmental regulations, water quality concerns, and other requirements. Management of water purchases and sales, local conjunctive use, water use efficiency, and water reuse must be increasingly coordinated with different agencies to meet water deliveries, conveyance, and storage constraints. In recent years, local, regional, statewide, and federal water management institutions have shown increasing flexibility and coordination of their water planning and operation decisions more closely than ever before.

- **California’s demands and expectations for technical analysis are increasing.** The increasing number of parties and interests involved in water management raises the level of scrutiny and expectations on technical analyses. The credibility of modeling results supporting water management decisions is questioned more often. The highly pluralistic, complex, and flexible nature of water management in California poses a challenge to technical analyses. At the same time, recent legislation has led to modeling results taking on an accounting function in assuring local water supplies required for new urban developments, leading to still greater scrutiny of modeling results.

Water management in California involves many interests. Negotiations, contracting, and operation planning could all benefit from reliable, consistent, and well-documented quantitative analyses. A higher confidence in modeling results allows managers and policy-makers at all levels to make local, regional, and statewide decisions with a better understanding on how different systems would affect each other. The development of a comprehensive set of reliable data and modeling tools is often beyond the capabilities of any single agency. It requires involvement from many parties (Close et al 2003; Ferreira et al. 2004, 2005).

A comprehensive strategic analysis framework is critical as a guide to the development of data and models to support water resources management, planning, and policy. What are the requirements on data and models to assure effective technical analyses? How should such models be developed and used to support the increasingly difficult and controversial policy, planning, and operational decisions at local, regional, and statewide levels? Appendix A discusses the more fundamental needs for technical analyses that would provide guidance in addressing these questions.

The performance of California’s water system depends on how well the water community collects, manages, and uses data and models for California’s complex and decentralized system. The development of models must be undertaken with explicit involvement from local, regional, and statewide interests. This report is a first effort to address these issues in a comprehensive manner.
III. FUTURE WATER MANAGEMENT ISSUES

California faces many water management challenges, each requiring specific data and modeling to address. Participants in a Modeling Forum workshop in August 2005 identified the key California water management issues:

A) State and Federal Investments: What can a specific water management investment achieve for environmental, urban, and agricultural purposes under different scenarios? The California Water Plan, the CALFED process, and other planning efforts identify and analyze investment options to address California’s water-related problems. These proposals require detailed quantitative analyses of alternative operations and management of infrastructure options. The system these studies address are more complex than the more centralized State Water Project (SWP) and the Central Valley Project (CVP) system existing models were designed to simulate. At the same time, how local and statewide water systems can be coordinated to improve their overall performance poses a challenging question.

B) Urban Water Supply Reliability: What is the best approach to secure a reliable water supply to meet urban needs and promote economic growth, consistent with environmental protection and agricultural prosperity? As water demand increases, local and regional water suppliers will be asked to provide firm and well-substantiated water supply guarantees for new developments. Recent California Senate Bills SB610 (Costa) and SB221 (Kuehl) in the 2001-2002 Session are perhaps forerunners of more demanding legal requirements of a reliable water supply. Assurances of water supply are likely to be challenged unless supported by consistent and transparent quantification, including contingencies. Accounting for the reliable sources of local water supplies is not simple for most growing areas in California. Estimating the available water, especially during droughts, is difficult given inter-regional dependencies for water supply and water quality. California does not have the type of data and models that allow these types of questions to be answered on a consistent basis across regions.

C) Agricultural Water Security: How can agricultural water supply be managed to allow farms to remain productive and profitable while protecting the environment and urban prosperity? Agricultural water supply will continue to become integrated with environmental and urban water uses. Recent water market transfers between farmers and cities illustrate the high level of economic and supply dependency that is evolving among different water users. How can water be better managed so that farms and rural areas remain viable without adversely impacting environmental restoration and urban economic prosperity, especially during droughts? What facilities, operational changes, water use changes, and institutional arrangements could provide a cost-effective basis for securing long-term agricultural productivity?

D) Environmental Restoration: How can California use water most effectively for environmental purposes while protecting agricultural and urban prosperity? Water management in California remains focused on independently meeting water supply, water quality, and environmental needs. A more integrated management of environmental uses and other beneficial uses of water could increase the overall utility of water for all beneficial use sectors. Models needed to explore such coordination are currently unavailable.

E) Climate Change: How should local, regional, and statewide water managers plan for likely changes in demand and hydrology due to changing climate? Management of water in California will need to change as the climate changes. However, we do not have a quantitative
understanding on how different climate change scenarios affect the water supply, water demand, and environmental needs in California. We are unable to provide consistent recommendations to local and regional authorities. Reliable predictions of hydrological sequence from regional climate models will likely remain unavailable into the foreseeable future. What approaches and analyses can be taken when only the general hydrologic trend is known?

F) Floods: What strategy for flood management should California adopt given floodplain urbanization, climate change, multiple demands on reservoirs, and limitations in flood forecasting? Flooding is a persistent problem in California and is expected to worsen. Flood control is closely tied with water supply, environmental, and other water management priorities. Reliable cost-benefit analyses of flood control options require greater technical capability than is currently available.

G) Water Right, Contract, Transfer, and Regulatory Accounting: How much water can a particular water right or water contract provide under different scenarios and regulations? As water demands continue to increase and water market transfers become more prevalent, a consistent approach to establish the quantities and timing of water delivery under contractual rights and applicable regulations will become critical. How reliable could complex water transfer options be analyzed under multiple constraints? California lacks the tools for consistent and adequately accurate accounting.

These issues pose many challenges to water management in California. From the modeling perspective, they add to the complexity in quantitative analyses. Each one of these issues must be properly accounted for in a reliable and consistent manner. For example:

- **Real-time, flexible environmental requirements** could only be simulated if management triggers in flexible, real time operations are properly accounted for.
- **Biological models** must be linked or integrated with hydrological and water quality (e.g., temperature) models to be useful to management decision processes.
- **New facilities** require a realistic simulation of changes in the operation of existing facilities under the new system.
- **Integrated system operations** require accounting for water deliveries and operations in different systems, such as the Colorado River, Tulare Lake Basin, San Joaquin Valley, and Sacramento Valley projects. Operational coordination within each valley poses an additional challenge.
- **Water transfers, options, exchanges, etc.** require integration of economic considerations and system limitations (e.g., conveyance capacity and regulatory standards) of each entity and accounting for the cumulative effects of multiple transfers.
- **A wide range of available water management options** creates a need to understand how to combine and integrate options to improve system performance. This is difficult to do without adequate models. Appendix B provides a list of the major water management options available to most water agencies in California.
- **The Environmental Water Account (EWA)** requires simulation of ill-defined operation criteria for the SWP/CVP system. The impacts of EWA on the market for water transfers require modeling capabilities covering multiple disciplines.
Conjunctive use requires simulation of system capacity limitations under multiple demands and political constraints.

Climate change requires analyses beyond the historical hydrology. Potential changes in drought sequences, flood control requirements, and Delta salinity changes due to sea level rise all require new modeling capabilities.

Catastrophic events could disrupt normal operations in large areas of the state for six months or more. Water project operations after major catastrophes, such as a massive earthquake-induced Delta levee failure, will likely be chaotic without adequate planning and feasibility analyses. A systematic evaluation of plausible scenarios requires additional flexibility in the modeling tools.

Uncertainty in modeling results and questions about their reliability are legitimate concerns for water managers and policy makers. Modeling results are subject to error and bias for a variety of reasons (Satkowski et al., 2000). How should the performance of water management options be evaluated when there could be considerable uncertainty and variability in the modeling results for water availability, water demands, and costs? How should uncertainty analyses be conducted for operations, planning, and policy studies? Multiple-scenario studies are desirable, but how should these be conducted, presented, and interpreted? Currently, formal uncertainty analysis is rarely done in modeling studies for California water management.

Existing models and data sets were not originally designed to address these contemporary and emerging needs. The credibility of modeling results is critical to management decisions. How can water policy, planning, and management discussions benefit from technical analyses? The technical basis supporting most policy discussions is fragmented and insufficient for the types of policy questions the water community are asking. If modeling results fail to gain wide acceptance, their roles and value in management decisions are diminished accordingly. A credible and broadly accepted data and modeling approach would greatly enhance the ability of water managers to explore and develop innovative solutions to water problems. If inadequacies in modeling capabilities are not addressed, the role of technical analyses in water policy and management decisions will decline. Without sound scientifically based analyses, operations, planning, and policy decisions would have to rely more on educated guesses and political considerations, becoming less transparent and efficient and more controversial and litigious.

Complex water issues take a long time to resolve. Development of a new facility or policy requires considerable time for institutional negotiations, compliance with legal requirements, financial arrangements, as well as construction. California must plan for future water problems and prepare for the challenge. Being able to use appropriate data and models broadens the variety of alternatives that the water community can evaluate with confidence.

IV. STRATEGIC ANALYSIS FRAMEWORK

The previous section highlights the need for a strategic analysis framework to guide the development of an appropriate database and a set of modular, linkable models to address increasingly complex water management challenges. Models and data sets must be designed and
implemented to work well together to allow integrated evaluation of the types of water management problems expected in the future. This section describes the key steps of a strategic analysis framework.

A strategic analytical framework is a set of standards and protocols that allow data and models to be developed and combined in a transparent and systematic way to address defined problems. The technical development of an analytical framework for data and model integration requires a detailed planning and design process. Once a conceptual blueprint of the framework is developed, the design and development of the actual data management systems and models could proceed with a focus.

Several efforts have been made to develop integrated analysis frameworks for water management studies. These efforts have been focused on different problems, in different regions, and have met with various degrees of success. A first step in our effort is to learn from these past and ongoing efforts and to adapt appropriate components into our own development for water resources management in California. Major on-going efforts consulted include:

- U.S. Army Corps of Engineers
  - Institute for Water Resources planning models
  - Basin-specific shared vision modeling
  - Central Valley Comprehensive Flood Control Study (USACE 2002)
- Center for Advanced Decision Support for Water and Environmental Systems (U.S. Bureau of Reclamation, Tennessee Valley Authority, University of Colorado, cadswes.colorado.edu)
- Spain’s national and regional modeling efforts (www.upv.es/aquatool/)

Review of these efforts and stakeholder input suggest that a framework must include the following five basic components:

1. **Purpose and Objectives**

California faces a wide variety of water management problems. A clear purpose and a concise set of objectives are necessary to guide the design and development of a strategic analysis framework. What are the most important questions the analysis framework will be asked to evaluate? Given the dynamic nature of California water, these questions should be fairly broad. Narrowly focused questions are less likely to retain their policy relevance over the long term. Major objectives will need to be identified in enough detail to provide guidance to the designers of the databases, models, and communication tools. However, detailed objectives will be developed only after the institutional and funding arrangements are defined. The applications discussed in Section III and in Appendix A provide a starting point for discussion.
2. Data Review and Management

A well-organized data management system supports major modeling objectives by providing well-documented, searchable descriptions of water, environmental resources, and infrastructure information. The conceptual blueprint for the strategic analysis framework would include detailed specifications for a data management system.

This data review and management effort differs fundamentally from most other existing water data activities intended for monitoring, hypothesis-testing, and compliance purposes. It would be developed with modeling applications as the key purpose. It would focus on the development, documentation, and testing of data sets that are used as input to models and for verifying model accuracy. These focuses differ from those of databases designed for monitoring or enforcement purposes. Error characteristics of data used for modeling purposes are especially important for several reasons. Systematic bias in the data over an extended period (for example, when maintenance for a sensor or recording instrument lagged and data quality deteriorated) would make model calibration and validation difficult. Equally important, the error characteristics of field data must be quantified if they are to be used for comparison with model output, error analysis of model results, or data quality improvement efforts. Furthermore, errors in input data will propagate, and possibly magnify, when different models are used sequentially.

The spatial representation and resolution in the database are important design criteria. The data structure should allow various spatial levels of representation, be GIS-based, and be searchable based on various hydrologic definitions. Presentation of analytical output on a GIS map, possibly with animation, will facilitate the analysis of model results. The temporal resolution is also an important issue, as operations and economic models operate on different temporal scales. How data of a coarser temporal resolution should be interpolated, if it could be interpolated, for input to models with a finer temporal resolution must be addressed.

A plan for data coverage must be part of the initial design. Data documentation, transparency, quality control, and uncertainty are important parts of the design criteria. Data quality problems are generally well known among data collectors, but they are rarely documented in a systematic way to data users. A scheme for characterizing data uncertainty and systematically improving data coverage and quality must be incorporated. Maintenance and data access protocols are essential.

3. Modular Models and Communications Tools

The strategic analysis framework must define an integrated set of models that provides adequate information to address policy, planning, and management questions of interest to local, regional, and statewide planning. Communications tools should be developed as companions to these “number crunching” tools to better allow policy-makers and their staffs to understand analytical results. The information conveyed should include a discussion of the uncertainties in (1) modeling results due to uncertainties in future scenarios, (2) water communities’ understanding of the system, (3) input data, and (4) approximations used in the model algorithms. The models and communications tools will be designed based on technical feasibility into the foreseeable future.

The Modeling Forum is not aware of any integrated database and set of models developed for statewide water management in other states and countries. The CalSim-II model covers the federal Central Valley Project and the State Water Project, but does not include major parts of...
California’s water supply system. The Corps of Engineers, the State of Texas, and others have developed such analytical systems for particular projects or regions. The closest example for California may be the integrated databases and economic-engineering optimization model CALVIN, developed at the University of California, Davis (Draper et al 2003; Jenkins et al 2001). This research and screening tool has provided a proof-of-concept for the value of integrated databases and analysis, but has many well-documented limitations (Jenkins et al 2001).

The preliminary conceptual design must cover several currently disconnected technical domains, including operations, surface hydrology, groundwater, urban economics, agricultural economics, water quality, biology, ecosystem, and social studies. Appendix C describes the wide range of technical domains that must be included to develop a comprehensive strategic analysis framework. Models in each of these domains must be developed with spatial and temporal representations and input and output specifications allowing them to be systematically linked to or integrated with other models in “upstream,” “downstream,” or feed-back relationships, such as surface hydrology model results becoming inputs to water quality, fish population, or operations models. Models with variable spatial and temporal resolution and coverage would be of particular interest.1 The experience of the European Union’s Water Framework Directive, the HarmonIT Project, and the U.S. Army Corps of Engineers’ (water management models and databases) CWMS effort could provide useful insights and ideas for adoption in California.

The design of screening tools, whether for simulation or optimization purposes, should be based on more detailed models. These tools are needed to identify promising alternatives from a large number of options within a reasonably short time frame. The promising alternatives can then be refined and tested with the more detailed and carefully verified models.

Another aspect of the conceptual design of models will be the development of preliminary protocols and guidelines for model development and use. A previous effort of the Modeling Forum (Satkowski et al 2000) could be revised for this purpose. In addition, models should be designed such that new research results and improved understanding of the system could be easily incorporated into the model algorithms and/or input data.

4. Institutional Support and Funding

A wide variety of institutional forums are potentially available to develop, implement, and adapt a strategic analysis framework. Texas has developed an extensive and integrated approach to quantify understanding of that state’s water availability, demands, and management (see www.twdb.state.tx.us/rwpg/planning_page.asp; Wurbs 2005, in press).

Texas’ analytical framework consists of a set of standardized regional models for surface water availability, groundwater availability, and water demands. While this approach has limitations, Texas is well ahead of California in the types and consistency of information being developed. The following excerpt outlines Texas’ approach to groundwater management:

“During the 76th Legislative Session, the Texas Legislature, recognizing the importance of accurate groundwater availability estimates, approved initial

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1 The feasibility to use detailed, accurate models as screening tools by reducing the spatial resolution and/or coverage (to reduce computation time) would be a highly desirable feature. Alternatively, two sets of tools could be considered. Each approach has advantages and disadvantages.
funding for the Groundwater Availability Modeling (GAM) program. The GAM program's goal is to provide reliable and timely information on groundwater availability to the citizens of Texas. The GAM program will result in standardized, thoroughly documented, and publicly available groundwater models. These models will be important tools for Regional Water Planning Groups and Groundwater Conservation Districts to evaluate water-management strategies and to assess present and future groundwater availability under normal and drought conditions.

Stakeholder involvement is critical to the success of the GAM program. Stakeholders, participating in Technical Advisory Groups (TAGs), are relied upon to voice concerns and provide information. Stakeholder input ensures that the models address the important water-resource issues concerning them for each major aquifer. TAGs typically consist of representatives from Regional Water Planning Groups, Groundwater Conservation Districts, the Texas Natural Resource Conservation Commission, the Texas Department of Agriculture, the Texas Parks and Wildlife Department, industry, water utilities, higher education, agriculture, and private landowners."

(From: www.twdb.state.tx.us/publications/newsletters/waterfortexas/wftwinter00/article4.htm)

As pointed out in the Texas example, any framework development process should be broad-based, involving agencies and expertise from all levels. Policy and technical committees representing major technical and policy expertise for California’s water management will help ensure that the framework and products are comprehensive, enjoy broad consensus among stakeholders, and are likely to become standard for water management analysis. Spain has a somewhat similar approach to developing analytical capability for its national and regional water plans, where a single academic developer provides most of the software and modeling technical support (Andreu, et al. 1996).

Various institutional support and funding options can be explored. Some options include:

i) **Consortium of agencies**
Create a stand-alone data and model development organization consisting of a consortium of data and model development institutions. This consortium would report to a Board of Directors and not directly to any single agency manager. The products from this consortium would be the authoritative data and models for all water related management purposes in California. This consortium could begin by focusing on a limited scope of data and model domains, which can later on be expanded if the initial effort is successful. The Consortium would adopt, maintain, and implement a strategic analysis framework, and oversee the development of data and models and protocols for their applications.

ii) **Analysis coordination group (“Consortium Lite”)**
Establish a small formal coordination group consisting of major modeling agencies, with a small, but mostly senior staff. This coordination group would direct and oversee all major data and model development for local, state, and federal purposes. The group would report to a Board of Directors consisting of major agencies and stakeholders.
iii) Independent research and development unit hosted by a research institution
Similar to some aspects of Texas’ and Spain’s approach, an academic institution (e.g., the University of California) or a research institute would host an independent research and development unit with staff and support from participating agencies. This alternative is similar to the consortium approach, except that another institution would host that unit. This arrangement might be better suited to attract and retain data and modeling expertise and to establish public/private partnerships, especially those that deal with information technology.

iv) State modeling program
The state legislature would specify an institutional structure for the development of a standard set of models and databases and protocols for their applications. The discussion on the Texas Groundwater Availability Modeling Program above provides an example of this approach.

v) MOU of modeling BMPs, with an enforcement/inspection mechanism
A set of best management practices (BMPs) for data and analytical tool development and use would be established and agreed upon by the major agencies in a Memorandum of Understanding (MOU). The MOU will also address how data and model developments in different agencies will be coordinated.\(^2\) It would be overseen by an independent group. This approach is currently used in urban water conservation effort, in which the California Urban Water Conservation Council (CUWCC) oversees the MOU of best management practices.

vi) CBDA analysis coordination group
The California Bay Delta Authority (CBDA) would establish an analysis coordination group, similar to the CBDA “Ops Group,” to coordinate data and model development, standards, and protocols among agencies and other stakeholders. While the CBDA would require the use of these standards for CBDA studies, they are likely also to become the standard for other agency studies.

vii) Legislative requirements for funding recipients to adhere with data and modeling principles
State and federal budget acts, and state bond funding legislations would require funding data and modeling recipients to adhere to a set of principles (see section IV.5 below).

viii) New DWR Division for data and models development
The California Department of Water Resources (DWR) would reorganize and form a Division of Analytical Services. This new Division would manage all data and model activities. The Division would consult with an external advisory board consisting of stakeholders from different sectors. This alternative provides DWR with consistent data and model development with explicit input from external stakeholders.

ix) DWR analysis coordinator and committee
A DWR coordinator supported by limited staff would report to DWR’s Director. The coordinator would be a deputy director or senior manager responsible for budgets and technical direction for data and model development within DWR. S/he will be advised by an external committee as a channel for input from non-DWR stakeholders. This alternative is a scaled-down version of the previous alternative.

\(^2\) An example is the federal framework for facilitating cooperation and coordination on environmental models (www.iscem.org/Memorandum.htm).
x) Expansion of DWR-USBR cooperation to other groups and modeling domains
The recent collaborative effort between DWR and the US Bureau of Reclamation (USBR) to
develop the operations planning model CalSim-II has been successful. This state-federal
cooperation would be expanded in phases to include other major data and modeling efforts and
include other modeling domains.

xi) Continued and expanded Modeling Forum efforts
The Modeling Forum would expand its work to facilitate voluntary coordination of data and
modeling activities. The Modeling Forum has been and will continue to be an active forum for
the discussion of technical issues and peer-review efforts. It could take on strategic and
implementation roles if the major agencies so prefer and authority and resources are delegated
accordingly.

xii) No change. Each agency proceeds at its own pace and interest
This is the no action alternative where each agency develops and uses data and models at its own
pace and interest. We are all familiar with how this works.

xiii) Other Alternatives / Combinations of the above alternatives
Since the alternatives discussed above are not mutually exclusive, some combinations could be
pursued at the same time. A superior alternative might emerge from brainstorming sessions
involving technical staff, managers, and policy makers.

There are advantages to a framework that is non-dictatorial and does not stifle innovation. At the
same time, it must encourage convergence and consistency in technical work. In addition to
defining a clear arrangement of authority, funding, expertise, and activities, the institutional
framework should also support the development, education, and improvement of modeling
professionals.

5. Principles for Model and Data Development
The issues discussed in sections IV.1 through IV.4 have been summarized into a set of common
principles (CWEMF 2004). These principles apply to all major model and data developments
and applications. They provide a foundation for both technical analyses and the use of the
results for policy decisions. They define expectations of analytical work which technical and
scientific professionals, water managers, and policy-makers can all understand and adhere to.

The 17 principles fall into five key areas, summarized in Table 1 and further discussed in
Appendix D. While the exact vision of desirable technical analysis capability has yet to be
fleshed out, the Modeling Forum believes such principles can help structure our long-term
technical thinking, provide basic understanding between technical staff and water managers,
policy-makers, and stakeholders, and provide directions to help move the data and models from
what we have today to what we would like to have in the future, regardless of the particular
technical problems to be addressed.
Table 1: Principles for Development and Use of Analytical Tools and Data

**Strategy:**
1) Data and analytical and communications tools should be based on expected long-term water problems and the decision-making processes they are expected to inform.
2) A strategic analysis framework should identify the technical objectives, roles, and responsibilities of major data collection efforts and models.
3) Strategic documents should be prepared and made available to the public. They should undergo periodic internal and external review, with substantial input from stakeholders, to identify needs for additional analytical tool and data development.
4) A frequently updated implementation document should outline short-term and long-term efforts, budgets, and responsibilities for continuous improvement of models and data. A sustained process for stakeholders input should be defined and adopted.

**Transparency:**
5) All data and models should have sufficiently detailed documentation.
6) Known limitations and appropriate applications should be documented.
7) Model applications should include explanatory & self-critical discussions of results, including uncertainty analyses.
8) Data, models, and major reports should be in the public domain, available on the web, and regularly updated.
9) A common glossary of key terms and acronyms should be maintained.

**Technical Sustainability:**
10) Modularity: Major models should be designed and implemented to fit modularly in the larger strategic analysis framework, allowing models to be tested, refined, updated, and replaced without major adjustments to other components.
11) Adaptive information management framework: Major data and information efforts should fall within a larger information management framework, including protocols for data documentation and updating, and documentation of limitations.

**Coverage:**
12) The spatial coverage of the basic data and analytical framework should be statewide and encompass a wide variety of water management options and processes.
13) Local and regional water management interests and resources should be explicitly represented to allow consistency among local, regional, and statewide studies.

**Accountability and Quality Control:**
14) Explicit testing should be done, documented, and available for major models.
15) Protocols and guidelines for model use should be developed and adhered to.
16) Major analytical products should be reviewed by both external experts and local agencies whose systems are included in the model(s).
17) In developing and maintaining models, serious efforts should be made to involve local agencies and stakeholders, including users groups or other cooperation mechanisms.
The five principal areas are:

- **Strategy** – Data, models and communication tools should be developed and integrated as part of a broadly based strategic effort focusing on likely future water problems in California. This strategy should be documented, updated, and coordinated with major modeling and stakeholder groups.

- **Transparency** – Data and models should be documented in a self-critical way so limitations are better known and considered. Documentation should be available to public scrutiny.

- **Technical Sustainability** – Data and model development are long-term efforts that must incorporate advances in scientific knowledge and the water communities understanding of water problems as they become available. Models and data should be developed in a strategic modular way.

- **Coverage** – Water management issues in California involves not only statewide activities and processes, but also local and regional activities and processes. Consequently, California needs a statewide concerted effort to integrate the problems, resources, opportunities, and expertise available at local and regional levels.

- **Accountability and Quality Control** – To improve the quality and transparency of model applications, models must be ground-truthed with the help of local experts. Protocols for model use and documentation, including limitations, must be developed.

V. PROPOSED ROAD MAP

The development of a strategic analysis framework for data and model development and integration requires a detailed planning and design process. These processes require institutional and financial support. To a large extent, the institutional and funding arrangements shape the detailed objectives and the blueprint for the framework development. Once the blueprint is complete, the specification of the data management system, models, and more detailed institutional and financial arrangements can be developed.

The Modeling Forum will continue to work with the water community to further develop alternatives and build support for institutional and financial arrangements. In the mean time, a few small, but significant first steps could be taken. These immediate goals require relatively modest financial resources, and the Modeling Forum will work with interested agencies to further develop and implement these projects where feasible. The Modeling Forum will continue to organize workshops to share information and solicit further input as progress warrants. As a start, technical workshops will be organized to review recent efforts to develop coherent data and models for major infrastructure management enterprises, and how these approaches may be adapted for a state-wide modeling framework.

At the same time, the Modeling Forum will continue to seek funding for several tasks that are fundamental to long-term models and data development in California, but require substantially more resources. The Modeling Forum is open to participating as lead, co-lead, collaborator, or resource in these efforts.
The next steps include both immediate goals and longer-term efforts in the following four categories.

1) Purpose and objectives

Immediate Goal 1: Stakeholder Process

The Modeling Forum will continue a process to define long-term purpose and objectives through workshops and discussions with stakeholders and agency staff with long-term interests in water management. Input will be sought from users of technical information from water agencies (including local, regional, state, and federal), environmental interests, and other stakeholder groups. The Modeling Forum will strive for concurrence and endorsement from key responsible agencies to assure their support and collaboration. Sufficient details will be developed to allow designers of databases, models and communication tools to assess the feasibility of the framework.

Deliverable: A written purpose and objectives document.

Resource needs: Active participation from Modeling Forum members is essential. Contact persons and assistance from key agencies would greatly facilitate the process.

2) Data review and management

Immediate Goal 2A: Review data management efforts

The Modeling Forum will work with interested agencies to develop, and implement where feasible, a project to review the achievements and lessons learned in developing large databases in other states and countries. For example, multi-million dollar efforts were made to compile data collected in the Snake River, Idaho, the Colorado River, and Tampa Bay, Florida. This project will aim to document the successes and problems encountered in these efforts based on input from the developers of individual databases. The findings will aid development efforts in California.

Deliverable: A report describing selected database developments in other states and countries.

Immediate Goal 2B: Data Quality Assessment

The Modeling Forum will work with interested agencies to develop, and implement, where feasible, a project to assess the quality of data available in California’s major publicly accessible databases. This effort will document known problems and estimate data accuracy based on input from data collectors and users. The goal is to identify the sources of error and quantify their magnitudes. If possible, automated procedure(s) to identify faulty data will be proposed. The effort also will evaluate each data program with regard to its conformity to applicable principles in data development discussed in Section IV.5 and Appendix D.

Several efforts to inventory existing databases have been made recently. For example, DWR’s Municipal Water Quality Investigations Program compiled a list of water quality measurement programs in the Central Valley, Delta, and San Francisco Bay (DWR, 1998). In addition, the California Water Plan has set up a web page for information exchange (the “Water PIE,” at www.waterplan.water.ca.gov/waterpie/index.cfm), which lists major California databases that are publicly accessible. Unfortunately, most of these databases provide only the raw data, with little or no documentation of data quality and error. Whereas problems in data quality may be
well known among data collectors, they are rarely disclosed systematically, and data users often have to learn about them the hard way.

**Deliverable:** A searchable web page documenting the quality of data in major California databases.

**Resource needs for immediate goal 2A and 2B:** Both efforts would be appropriate for Master’s thesis level work in a graduate school program. Matching funds from other agencies will be sought, and the available funds will determine the level of effort. Alternatively, the work could be performed by agency staff or consultants with the appropriate expertise.

**Additional tasks contingent upon external funding**

a) Assemble and further develop GIS-based land-use data for water demand and hydrologic inputs for statewide water management. Several broad areas of data needs have been identified in previous efforts. A GIS-based database of California’s water system will allow various spatial levels of representation of hydrologic data. Spatial representation of modeling output will also be developed.

b) Develop a more refined conceptual design for data management within an institutional framework. This design includes identifying major data needs and a setup that would allow continuous updates and data sharing among different databases throughout California. The databases will provide a quantitative, electronically documented, and searchable description of water and water management for identified modeling purposes. Data documentation, quality control, and uncertainty estimates will be important parts of the design.

### 3) Modular models and communication tools

**Immediate Goal 3A: Review model and data communications tools**

The Modeling Forum will work with interested agencies to develop, and implement where feasible, a project to review the achievements and lessons learned in developing modular modeling and communication tools in other states and countries. During the last ten years, many agencies have investigated modular modeling and communication tools (see list in the introduction in Section IV), including the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the Federal Emergency Management Agency, and the European Union. Their experience and work products could offer insights into the feasibility and promising approaches of modular modeling and communication tools.

**Immediate Goal 3B: Further develop modeling protocols and guidelines**

The Modeling Forum will update and further develop its previous report on the protocols for water and environmental modeling (Satkowski et al., 2000). The goal is to provide more specific technical and procedural guidance to develop and use models, consistent with the principles discussed in Section IV.5 and Appendix D.

**Deliverables:** A written report for each of the two projects.

**Resource needs for immediate goal 3A and 3B:** The first project will be appropriate for one or more Master’s thesis in a graduate school program, depending on the scope of work. Active participation from Modeling Forum members is essential for the second project. Available
resources will determine the level of effort. Alternatively, the work could be performed by agency staff or consultants with the appropriate expertise.

Additional tasks contingent upon external funding

Develop preliminary technical designs and specifications for an integrated set of models and communication tools, and a plan for their development. This would consist of a set of integrated models to provide decision support for policy, planning, and management questions of local, regional, and statewide importance. An important aspect of this design is to quantify uncertainties in future scenarios and in the water communities’ understanding of the system. The types of models developed would depend on what is technically feasible in a ten-year or longer time frame.

The preliminary conceptual design must cross several currently independent technical domains, including operations, surface hydrology, groundwater, urban economics, agricultural economics, water quality, biology, and ecosystems. In particular, California must develop models in each of these domains with spatial and time scales and input/output specifications that allow them to be systematically linked with other models in “upstream,” “downstream,” or feedback modes.

4) Institutional and financial support

Immediate Goal 4: Stakeholder process

The Modeling Forum will continue discussions with major parties to establish long-term institutional support and funding to develop and implement a strategic analysis framework for water management in California. It will continue discussions with stakeholders and data management and modeling groups to generate support for integrated data management and analytical tool development and improvement. Through workshops and other communications, the Modeling Forum will update stakeholders and interested parties on the progress of ongoing data and modeling efforts, and the feasibility of the framework.

The success of the effort depends on many factors. The Modeling Forum would make every effort to:

- Respond to stakeholders’ long-term modeling needs
- Promote the modeling principles discussed in Section IV.5 and Appendix D to stakeholders and technical interests
- Attract broad technical staff participation from local, regional, and statewide interests and agencies
- Work with key agencies to develop institutional and financial supports.

Institutional governance and financial support are the most challenging aspects of the proposed framework. They require broad buy-ins and compromises. However, the success of the effort would depend on an arrangement that:

- Establishes the legitimacy of the approach and broad institutional support
- Secures at least a quasi-independent institutional arrangement
- Develops the ability to contract and supervise external expertise in the academic and in both private and public sector
- Attracts and retains technical staff
• Educates technical staff on the data and models used to analyze and understand California’s complex water system

_Deliverable:_ Report with a feasibility analysis in sufficient details to allow for legislation and policy developments.

_Resource needs:_ Active participation from Modeling Forum members is essential. Contact persons and assistance from key agencies would greatly facilitate the process.

### VI. CONCLUDING THOUGHTS

*Hope is like a road in the country; there was never a road, but when many people walk on it, the road comes into existence.*

– Lin Yutang

*An analysis framework is like a path in the country, there was never a path, but when many people walk on it, the path comes into existence.*

– Pete Pivo

*The path could lead far, or just go round and round, it’s up to the people who walk it, to decide if they want it to lead somewhere.*

– Pete Pivo

*Let the work begin!*
Background Readings and References


DWR (2003), Delta Modeling Section Strategic Plan, Delta Modeling Section, California Department of Water Resources, Sacramento, CA, 8 pp.


Texas Water Development Board (TWDB), State of Texas water planning website, www.twdb.state.tx.us/rwp/lgplanning_page.asp


Appendix A

Why Use Quantitative Analysis for Managing Complex Systems?

Data and models are essential for managing large complex systems. They support operational decisions and planning processes in all major transportation, industrial, or utility systems. Southwest Airlines, Dell, and Boeing are examples of private enterprises that have increased their effectiveness and lowered their costs with extensive and intensive use of quantitative analysis for operational, planning, and policy purposes. In large decentralized utilities such as electric power and water resource systems, data and models quantify the interactions among semi-sovereign but interdependent system components. Data and models serve many purposes including the following:

1) **Forum for integrated learning about the system.** A computer model is an integrated representation of our understanding of a system. As such, it forces us to assemble a self-consistent replicable quantitative description of a system. An analysis framework allows decentralized expertise on individual aspects of the system to be formally integrated.

2) **System to progressively test hypotheses and improve understanding.** Our understanding of large, complex, decentralized systems will always be limited, and our strategies to operate the system must address many uncertainties. Computer modeling allows system managers to experiment with different aspects of the system to better understand the system’s components and their relationships, and how uncertain future conditions affect various processes and solution approaches. It is easier to learn from mistakes (or unexpected results) if our understanding of the system is formalized and can be tested quantitatively.

3) **Aid in developing alternative management solutions.** Integrated understanding of a system is essential for developing management solutions. Modeling results allow potential solutions to be explored without the time, expense, coordination, logistics, and risks required for testing in the actual system. Models also provide a more controlled environment than field testing.

4) **Basis for comparing management alternatives.** The formal comparison of alternatives and their performance is fundamental to making rational choices. Computer models support expeditious, cost-efficient, standardized, and consistent comparison of alternatives.

5) **Accounting framework for contracts, agreements, and regulations.** Some infrastructure systems are too complex for operational accounting to be based directly on field monitoring. Comprehensive field monitoring is often too costly and unreliable to form a basis for binding contracts and agreements. Computer modeling provides a consistent basis for operational accounting, if the models are sufficiently accurate.

6) **Quality assurance.** Modeling allows alternatives to be analyzed in an objective and systematic manner. Data and modeling studies could be a cornerstone in a formal and documented decision process that could be understood by all interested parties.
Appendix B

Water Management Options and Integrated Management

Local, regional, and statewide water managers are using a variety of water management options that are further complicated by decentralized decision-making. Table B provides a list of these options. This complexity makes the use of modeling essential to the development and implementation of water management options.

<table>
<thead>
<tr>
<th>Table B. Summary of Available Water Supply Management Options</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demand Management and Allocation</strong></td>
</tr>
<tr>
<td>General</td>
</tr>
<tr>
<td>Pricing</td>
</tr>
<tr>
<td>Subsidies, Taxes</td>
</tr>
<tr>
<td>Regulations (allocation, water quality, contract authority, rationing, etc.)</td>
</tr>
<tr>
<td>Water transfers, options, markets, exchanges (within and/or between regions/sectors)</td>
</tr>
<tr>
<td>Insurance (drought insurance)</td>
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<tr>
<td><strong>Demand Sector Options</strong></td>
</tr>
<tr>
<td>Urban water use efficiency</td>
</tr>
<tr>
<td>Urban water scarcity (reduce demand through pricing or rationing)</td>
</tr>
<tr>
<td>Agricultural water use efficiency</td>
</tr>
<tr>
<td>Agricultural water scarcity</td>
</tr>
<tr>
<td>Ecosystem restoration/improvements (dedicated flow and non-flow options)</td>
</tr>
<tr>
<td>Ecosystem managed water use efficiency</td>
</tr>
<tr>
<td>Environmental water scarcity</td>
</tr>
<tr>
<td>Recreation water use efficiency</td>
</tr>
<tr>
<td>Recreation improvements</td>
</tr>
<tr>
<td>Recreation scarcity</td>
</tr>
<tr>
<td><strong>Supply Management</strong></td>
</tr>
<tr>
<td>Operations Options (Water Quantity and/or Quality)</td>
</tr>
<tr>
<td>Conjunctive use of surface and ground water</td>
</tr>
<tr>
<td>Surface water storage facilities (new or expanded)</td>
</tr>
<tr>
<td>Cooperative operation of surface facilities, operational changes</td>
</tr>
<tr>
<td>Conveyance facilities (new or expanded)</td>
</tr>
<tr>
<td>Conveyance and distribution facility operations</td>
</tr>
<tr>
<td>Supply Expansion Options (Water Quantity and/or Quality)</td>
</tr>
<tr>
<td>Supply expansions through operations options (e.g. reduced losses and spills)</td>
</tr>
<tr>
<td>Agricultural drainage management</td>
</tr>
<tr>
<td>Urban water reuse (recycling)</td>
</tr>
<tr>
<td>Water treatment and desalination</td>
</tr>
<tr>
<td>Urban runoff/stormwater collection and reuse (in some areas)</td>
</tr>
</tbody>
</table>
Appendix C

Domains of Data and Models

Water management in California is becoming more complex and involves many physical, water quality, biological, ecological, economic, and institutional processes that interact at different time and geographic scales. This poses challenges to the analyses and developments of water management alternatives and requires quantitative models that span different technical domains. The range of these domains is illustrated in Table C. Temporal and spatial scales and uncertainty estimates in models from different domains must be compatible when these models are used in an integrated analysis.

Table C. Technical domains of data and models

1. Water Demands (including economic, biological, and other performance valuation)
   - Agricultural
   - Environmental
   - Urban
   - Hydropower
   - Recreation
   - Land use (GIS)
   - Others?
2. Facilities (capacities, connectivity, water losses, variable costs; essentially a database)
   - Surface reservoirs
   - Aquifers
   - Conveyance (streams, aqueducts)
   - Pumping
   - Hydropower
   - Treatment
   - Wastewater reuse
   - Desalination
   - Artificial recharge
   - Junctions
3. Hydrology
   - Surface Water – rim flows; local inflows
   - Groundwater
4. Water quality
   - Estuary
   - Groundwater
   - River and canal
   - Lake/reservoir
   - Return flow and local source
   - Treatment
5. Water Management/operations (how to operate facilities: local, regional, statewide)
   - Water deliveries – spatial
   - Water operations – temporal
6. Experimental domains (Ecosystem processes; fluvial geomorphology, etc.)
7. Multi-domain models (spanning several domains)
8. Post-processor(s), graphics, and visualization for presenting and comparing results
9. Post-processor for evaluation of alternatives on performance objectives
10. GIS interface (Land use depiction of results, display of assumptions, and pre-processing and post-processing of data)
11. Data management, quality control, and documentation
12. Interpretation, synthesis and communication to various audiences
Appendix D

Principles for Analytical Tool and Data Development and Use

The interim report in this Modeling Forum effort (CWEMF 2004) proposed 17 principles for long-term model and data development. While detailed requirements for technical analysis have yet to be developed, the proposed principles serve to frame the strategic plan and provide a common understanding between technical staff, water managers, policy-makers, and stakeholders. They provide a framework to map out the steps it would take to get to where we would like to be in the future, even though specific water management issues and data and models have yet to be defined in detail. The principles fall into five categories and are discussed below.

**Strategy:**

1) Data and analytical and communications tools should be developed based on expected long-term water problems and the decision-making processes they are expected to inform.

2) An official strategic analysis framework should identify the technical objectives, roles, and responsibilities of major data collection efforts and models.

3) Strategic documents should be prepared and made available to the public. They should undergo periodic internal and external review, with substantial input from stakeholders, to identify needs for additional analytical tool and data development.

4) A frequently updated implementation document should outline short-term and long-term efforts, budgets, and responsibilities for continuous improvement of models and data. A sustained process for stakeholders input should be defined and adopted.

Data, models, and communications tools are resource-intensive to develop and maintain. They would have more lasting value if they are designed to address a defined set of problems that decision-makers and stakeholders expect to have long-term importance. Strategic planning documents for data and models provide the general water community with a clear statement of the purpose of data and models. However, since problems, data, understanding, and modeling techniques change with time, strategic thinking should be adaptive and amended periodically.

Aside from informing stakeholders and decision makers of a particular model’s purpose, strategic documents provide a common understanding on what could be expected of models and data. Strategic documentation also serves to educate technical newcomers to better understand (1) the strengths, weaknesses, and limitations of the data and models, and (2) the intended context of their application.

The responsibility for developing and maintaining a strategy should be placed on an agency with a mandate for statewide water planning and accounting. The California Department of Water Resources would be a logical lead agency. However, input and close collaboration with all interested parties (e.g., through a multi-agency advisory group) would be critical to a sound strategy with broad support.

**Transparency:**

5) All data and models should have sufficiently detailed documentation.

6) Known limitations and appropriate applications should be documented.
7) Model applications should include explanatory and self-critical discussions of results, including uncertainty analyses.

8) Data, models, and major reports should be in the public domain, available on the web, and regularly updated.

9) A common glossary of key terms and acronyms should be maintained.

Analysis of water systems as complex and extensive as California’s will never be totally transparent, and will never be simultaneously simple and correct. No one person can understand this entire system, so it seems unrealistic for any one person to understand the entire set of models and data that represent the system. Nevertheless, greater and more systematic efforts at transparency in technical activities are needed to:

Enhance quality. Transparency allows analytical methods to be better understood, allows limitations to be more readily identified and addressed, and facilitates broader input for improvements.

Enhance credibility. Technical credibility rests on the assurance that each step in the analytical process has an empirical or derived basis and that each of these steps is well-reasoned and is discoverable, testable, and replicable.

Enhance sustainability. Technical personnel rarely work on technical details of the same model for more than a few years. However, models and data sets often have much longer life spans. Without systematic and detailed documentation, institutional memory for data and models may be lost, making it difficult for new technical staff to become sufficiently knowledgeable about specific details of the model or understand how the reasons behind specific approximations. This hampers further improvements and updates of a model, and gradually erodes the model’s value and credibility.

Self-critical discussion of a model and model results is essential to making useful and credible insights from unavoidably imperfect model results and provide a basis for improvements in data and models.

Technical Sustainability:

10) Modularity: Major models should be designed and implemented to fit modularly in the larger strategic analysis framework, allowing models to be tested, refined, updated, and replaced without major adjustments to other components.

11) Adaptive information management framework: Major data and information efforts should fall within a larger information management framework, including protocols for data documentation and updating, and documentation of limitations.

The complexity and changing nature of California’s water problems calls for a flexible and adaptive integration of data and model development. In a strategic analysis framework, individual models are modular and are (painstakingly) designed to have consistent assumptions and data structures. Well-defined algorithms are developed to interpolate or aggregate model output and field data between different temporal and spatial resolutions. Modularity allows one part of an analytical framework to be improved without having to modify the other aspects of a complex modeling system. Modularity also facilitates modeling at different levels of detail. Recent advances in object-oriented design make modular design much more attainable now than when many of the existing models were developed.
Confidence in model results depends in large part on the amount and quality of data available for model input, calibration, and validation. A comprehensive plan for data development and documentation is an integral part of a strategic analysis framework. The plan identifies and defines the process to collect additional data needed for long-term modeling activities.

Coverage:

12) The spatial coverage of the basic data and analytical framework should be statewide and encompass a wide variety of water management options and processes.

13) Local and regional water management and resources should be explicitly represented to allow consistency among local, regional, and statewide studies.

Water management problems in California have become highly interconnected. Conjunctive use and water conservation efforts in one part of the state are often tied to water use decisions elsewhere, with implications to water management operations in the areas in between. A statewide framework is essential to an adequate analysis.

Development of statewide coverage must be a cooperative enterprise. A comprehensive system can be constructed over time if local, regional, and statewide agencies all adhere to a consistent data and modeling framework and set of protocols. A coordinated approach could promote local and regional investments to improve quantitative capability throughout the state. A statewide framework provides a standardized and more credible basis for management studies for local and regional projects. It also provides a forum for local agencies and stakeholders to be involved and improve representations of their respective areas for regional and statewide analysis.

Accountability and Quality Control:

14) Explicit model testing should be undertaken, documented, and made available for major models.

15) Major analytical products should undergo review by external experts and local agencies whose systems are included in the model(s).

16) Protocols and guidelines for model use should be developed and adhered to.

17) In developing and maintaining models, significant efforts should be made to involve local agencies and stakeholders, including users groups or other cooperation mechanisms.

Quality control is essential for good technical work. The general public and policy-makers perceive the quality of data and models by examining the formal testing, documentation, use, and review procedures. These formal evaluations may be performed at different levels of detail and sophistication, depending on a particular model application.
Appendix E

Existing Data and Modeling Activity

Data and models are developed at state, federal, and local agencies for their water management needs with little coordination. Table E lists some of the major entities whose water management modeling activities would affect or require input from other systems.

Table E. Some of the major efforts to develop databases and models in California

<table>
<thead>
<tr>
<th>Entity</th>
<th>Efforts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Water Resources SWP Modeling Support Branch</td>
<td>Operations planning - CalSim-II, Delta hydrodynamics &amp; quality - DSM2, Groundwater - CVGSM/IGSM2</td>
</tr>
<tr>
<td>Department of Water Resources Department of Planning and Local Assistance</td>
<td>Economics - CALAG, LCPSIM, Urban water demand - IWR-MAIN, Agricultural water demands – SIMETAW, Real-time forecasting – DSM2</td>
</tr>
<tr>
<td>Department of Water Resources Environmental Services Division</td>
<td>Suisun Marsh hydrodynamics &amp; quality – DSM2 and RMA</td>
</tr>
<tr>
<td>Department of Water Resources Operations</td>
<td>Operations planning - CalSim-II &amp; DSM2</td>
</tr>
<tr>
<td>Department of Water Resources Flood Management</td>
<td>Runoff modeling and flood models</td>
</tr>
<tr>
<td>U.S. Bureau of Reclamation</td>
<td>Operations planning - CalSim-II, GIS, Temperature modeling, salinity drainage</td>
</tr>
<tr>
<td>U.S. Army Corps of Engineers</td>
<td>Real-time operations and flood control, flood mapping, risk assessment</td>
</tr>
<tr>
<td>California Bay-Delta Authority (CBDA)</td>
<td>Financial support for data and modeling efforts</td>
</tr>
<tr>
<td>California Department of Fish and Game</td>
<td>Instream flow modeling (particularly related to temperature)</td>
</tr>
<tr>
<td>Interagency Ecological Program</td>
<td>Raw data collection</td>
</tr>
<tr>
<td>Metropolitan Water District of Southern California</td>
<td>Operations planning – IRPSIM, Urban water demand – MWD-MAI</td>
</tr>
<tr>
<td>State Water Resources Control Board</td>
<td>Water rights data, Water quality data</td>
</tr>
<tr>
<td>Department of Health Services</td>
<td>Drinking water source and system inventory, Drinking Water Source Assessment and Protection</td>
</tr>
<tr>
<td>San Diego Water Authority</td>
<td>Planning models</td>
</tr>
<tr>
<td>Contra Costa Water District</td>
<td>Outflow-salinity model (the “G-Model”)</td>
</tr>
<tr>
<td>Santa Clara Valley Water Authority</td>
<td>Planning and operations planning models</td>
</tr>
<tr>
<td>California Urban Water Conservation Council (CUWCC)</td>
<td>Water conservation BMP implementation and water demand effects</td>
</tr>
<tr>
<td>U.C. Davis Information Center for the Environment (ICE)</td>
<td>GIS data, Urban land use models for Central Valley</td>
</tr>
<tr>
<td>U.C. Davis CALVIN group</td>
<td>Screening, facilities, &amp; operations planning - CALVIN</td>
</tr>
<tr>
<td>Local and regional water districts</td>
<td>Planning models and operational data</td>
</tr>
</tbody>
</table>
Survey of Irrigation Methods in California
By Morteza Orang, Richard Snyder and Scott Matyac, DWR and UC Davis
Survey of Irrigation Methods in California in 2001
Morteza N. Orang1, Richard L. Snyder2, J. Scott Matyac3

Abstract
This report discusses a statewide survey of irrigation methods conducted in California during 2002. The purpose of the study was to collect information on irrigation methods to determine which methods were used by growers to irrigate their crops in 2001. Reliable information on irrigation methods is an important factor for planning future water demand by agriculture irrigation based on trends. To conduct the survey, one-page survey form was developed to collect irrigated land (acres) by crop and irrigation method. Then a questionnaire was mailed out to 10,000 of the estimated 80,000 growers in California by the California Department of Food and Agriculture. The results from comparing earlier studies with 2001 indicated that the amount of land irrigated by drip irrigation method has increased by about 33%, while the amount of land irrigated by surface methods has decreased by about 31%. The area planted to orchards and vineyards has increased, while that planted to field crops has declined. The largest increase in sprinkler use has been in vegetable crops, an increase of 19% since 1972. The 1991 and 2001 statewide surveys exclude rice acreage.

Introduction
The application of water to soils for crop use is referred to as irrigation. Surface (gravity-driven surface irrigation), sprinkler, drip/micro, and sub-surface are types of irrigation methods that are used by growers to irrigate various crops in the state. The irrigation methods that growers use to apply water may affect the salt accumulation in the crop root zone (leaching), plant transpiration, soil evaporation, and runoff from soil surface. Irrigation performance is commonly measured by how much of applied water beneficially used for crop production. Irrigation (application) efficiency or consumed fraction is an index used to quantify the efficient use of water diverted to a field by an irrigation system and is defined as the ratio of that quantity of water stored in the root zone, which can be used in evapotranspiration to the amount of applied water as a percentage. Distribution uniformity (DU) is also an important element in irrigation water use efficiencies. DU is the measure of the uniformity of irrigation water distribution over a field. The most appropriate irrigation method for an area depends upon physical site conditions, the crops being grown, amount of water available, and management skill. The water management decisions strongly influence how uniform water can be applied through different irrigation methods to provide optimal soil water conditions for crop growth and marketable yields. The main objectives are to avoid water stress, achieve high yields and protect water quality. Water losses from irrigation vary with the type of irrigation method. In the absence of a reliable irrigation system, the water application is often non-uniform and is generally over applied, resulting in excess runoff and deep percolation below the root zone. If part of the

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field is over irrigated, the crop roots near the soil surface will be exposed to water that has salinity near that of the irrigation water rather than an average root zone soil salinity value. As a result, crop yields are generally more affected by the irrigation water salinity level than by the soil water salinity in the lower part of the root zone. However, the use of a proper irrigation method that fits the crop, water, and site conditions will ensure that losses are held to a minimum and subsequently, will result in high irrigation efficiency and distribution uniformity.

Runoff and deep percolation generally are greater for gravity systems than for well managed sprinkler and drip/micro irrigation methods. The combined losses of deep percolation and runoff for poor managed gravity irrigation system will lower consumed fraction and subsequently, will pollute the surface water and groundwater supplies. Sprinkler and drip/micro systems reduce runoff or deep percolation compared to gravity irrigation, because these type systems provide complete control over the amount of water applied to the field. As a result, water is distributed more uniformly within the intended root zone. Generally, more water is used with gravity and sprinkler irrigation on an annual basis than with drip/micro. According to the “Report on Evaporation from Irrigated Agricultural Land in California” by Charles Burt of CalPoly, gravity and sprinkler irrigation tends to wet larger fractions of the soil surface (0.6-1.0, or 60%-100%, of the soil surface is wet during a typical irrigation) than drip/micro systems. In addition, it is often difficult to control the application depth of irrigation water because of uniformity and scheduling constraints. Drip/micro has typical wetted fractions ranging from almost 0, for subsurface drip, to 0.8, for some micro spray on tree crops. A typical range for trees in California is 0.3-0.6 for surface drip/micro. Drip/micro is also considered to have more flexibility for irrigation scheduling.

Water resources project planning requires reliable estimates of crop and irrigation system combinations, which are important components in a variety of water budget analysis. To update California’s records on irrigation methods used within the state, a survey is conducted by the California Department of Water Resources about every 10 years. The gathered survey data is analyzed and compared with earlier surveys to study how irrigation methods are changing and to make projections of future changes for long-term planning.

The purpose of this report is twofold; (1) to demonstrate the reliability of the 2001 irrigation survey results on the number and type of irrigation systems used in California and (2) to present the results of our study comparing the earlier estimates to the 2001 estimates. Reliable information of current irrigation methods by various crops is extremely important for the California Department of Water Resources for planning its future water demand by agriculture irrigation based on trends. The absence of reliable information can severely limit its usefulness for long-term water planning purposes.

**Methodology**

Approximately every 10 years one-page irrigation survey forms are mailed out to many growers throughout California to conduct a statewide survey to update California’s records on irrigation methods. A statewide survey of current irrigation methods was conducted during 2002 to determine which irrigation methods were used in California during 2001. The 1991 was chosen as the base year to keep a 10-year period between this survey and the previous study done during 1972. Earlier surveys of irrigation methods had been conducted by Ian Stewart in 1972 and by Robert Hagan with California Department of Water Resources in 1980. In these studies, irrigated crop acreage was estimated by UC Cooperative Extension specialists and county farm advisors in each county. The 1991 and 2001 studies were conducted by mailing questionnaires to growers who were randomly selected from a list of growers. A list
of 58,000 of the estimated 80,000 growers in California from the California Department of Food and Agriculture (CDFA) was used to determine the mailing list. All rice-only growers were excluded from the list. Since valid data on the rice acreage for any given year is available and the irrigation method is flooding, collecting this information was unnecessary. Non-irrigated farms and large livestock ranches were also excluded from the survey. Growers were asked to state the main county in which they farmed and the acreages they had planted during 2001 to each of 20 possible crops by irrigation method within that county. Number and types of crops used in 2001 survey are slightly different from those used in 1979, 1980, and 1991. The 2001 survey of irrigation methods included a 20-crop category as opposed to 13-crop category used in 1991 survey. A list of crops used in 1972, 1980, 1991, and 2001 surveys are shown in Table 1. Note that the 1991 and 2001 surveys did not include rice, whereas 1979 and 1980 studies did include rice acreage (Table 1). Survey forms were mailed by the California Department of Food and Agriculture to an estimated 10,000 growers in 58 counties and there was a 35% useable return rate. A sample of the 2002 survey form is shown in Figure 1.

### Table 1. Crop types used in 1972, 1980, 1991, and 2001

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Alfalfa</td>
<td>Alfalfa</td>
<td>Alfalfa</td>
</tr>
<tr>
<td>Grain</td>
<td>Small Grains</td>
<td>Grain</td>
<td>Small Grains, Misc. Hay</td>
</tr>
<tr>
<td>Corn</td>
<td>Corn</td>
<td>Corn</td>
<td>Corn</td>
</tr>
<tr>
<td>Cotton</td>
<td>Cotton</td>
<td>Cotton</td>
<td>Cotton</td>
</tr>
<tr>
<td>Other Field Crops, Dry Beans, Safflower, Pasture, Turf grass and Landscape</td>
<td>Other Field Crops</td>
<td>Miscellaneous Field</td>
<td>Pasture</td>
</tr>
<tr>
<td>Almond &amp; Pistachio, Other Deciduous</td>
<td>Deciduous Fruits and Nut Trees</td>
<td>Deciduous Fruits And Nut Trees</td>
<td>Peaches &amp; Nectar/Prunes/ Almonds/Walnuts</td>
</tr>
<tr>
<td>Subtropical Trees</td>
<td>Subtropical</td>
<td>Subtropical</td>
<td>Citrus &amp; Avocado/Other Orchard</td>
</tr>
<tr>
<td>Sugar Beets</td>
<td>Sugar Beets</td>
<td>Sugar Beets</td>
<td>Sugar Beets</td>
</tr>
<tr>
<td>Tomato (fresh), Tomato (process)</td>
<td>Processing Tomatoes</td>
<td>Tomatoes</td>
<td>Tomatoes</td>
</tr>
<tr>
<td>Other Truck Crops, Onion &amp; Garlic, Potato, Cucurbit</td>
<td>Vegetables (Truck Crops)</td>
<td>Miscellaneous Truck</td>
<td>Beans, All Types/Potatoes/ Lettuce/Other Veg, Crops</td>
</tr>
<tr>
<td>Vineyard</td>
<td>Grapes And Bush Berries</td>
<td>Vineyard</td>
<td>Grapes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rice</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rice</td>
</tr>
</tbody>
</table>
Table 2 includes the individual and total irrigated land in acres by each crop and by each irrigation method in California during 2001 irrigation survey. The total irrigated land from 1991 and 2001 surveys is only 5%. This indicates an insignificant difference in irrigated land between the 1991 and 2001 surveys. The sample of 59,400 irrigated acres used to determine which irrigation methods growers used to irrigate their crops in 2001. The sample represents nearly 50% of the irrigated land in the state surveyed.
Table 2. - Statewide irrigated land (acres) by crop and irrigation method in 2001

<table>
<thead>
<tr>
<th>Irrigation Method</th>
<th>Corn</th>
<th>Cotton</th>
<th>Dry Beans</th>
<th>Grains</th>
<th>Safflower</th>
<th>Sugar beet</th>
<th>Other Field Crops</th>
<th>Alfalfa</th>
<th>Pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBSURFACE</td>
<td>4,183.00</td>
<td>381.00</td>
<td>0.00</td>
<td>583.00</td>
<td>315.00</td>
<td>0.00</td>
<td>24.00</td>
<td>1,545.00</td>
<td>1,505.00</td>
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<td>WILD FLOOD</td>
<td>1,842.50</td>
<td>0.00</td>
<td>20.00</td>
<td>1,926.30</td>
<td>258.60</td>
<td>0.00</td>
<td>200.50</td>
<td>1,278.50</td>
<td>11,118.7</td>
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<td>700.00</td>
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<td>3,425.00</td>
<td>48,076.50</td>
<td>10,255.40</td>
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<td>120.00</td>
<td>70.00</td>
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<td>0.00</td>
<td>0.00</td>
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<td>3,360.00</td>
<td>650.00</td>
<td>1,708.00</td>
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<td>321.00</td>
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<td>652.00</td>
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<td>0.00</td>
<td>15.00</td>
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<td>1,403.00</td>
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<td>0.00</td>
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<td>2,537.50</td>
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<td>0.00</td>
<td>0.00</td>
<td>6.50</td>
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</tr>
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<td>0.00</td>
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<td>0.00</td>
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<td>1.50</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</tr>
</tbody>
</table>
Table 2. - Statewide irrigated land (acres) by crop and irrigation method in 2001 (continued)

<table>
<thead>
<tr>
<th>Irrigation Method</th>
<th>Onion &amp; Garlic</th>
<th>Potato</th>
<th>Other Deciduous</th>
<th>Subtropical Trees</th>
<th>Turf grass &amp; landscape</th>
<th>Vineyard</th>
<th>Tomato (fresh)</th>
<th>Tomato (process )</th>
<th>Other Truck Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBSURFACE</td>
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<td>156.80</td>
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<td>151.50</td>
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<td>262.00</td>
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<td>5.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>10.00</td>
<td></td>
</tr>
<tr>
<td>SIDE-ROLL</td>
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<td>80.00</td>
<td>464.00</td>
<td>600.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>MICRO-MINI</td>
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<td>5,504.60</td>
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<td>1,045.20</td>
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<td>0.00</td>
<td>0.00</td>
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<td>CENTER - PIVOT</td>
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<td>100.00</td>
<td>57.00</td>
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<td>30.00</td>
<td>0.00</td>
<td>12.00</td>
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</tr>
<tr>
<td>ABOVE GROUND</td>
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<td>2,602.50</td>
<td>2,216.00</td>
<td>74.00</td>
<td>2,300.00</td>
</tr>
</tbody>
</table>
Percentage of statewide acreage reported for each crop was then calculated by each irrigation method. Table 3 illustrates the percentages of irrigated land by each of 20 crops and by four irrigation methods in 2001.

Table 3. Percentages of irrigated land area by crop and irrigation method in California in 2001

<table>
<thead>
<tr>
<th>Crop</th>
<th>Gravity</th>
<th>Sprinkler</th>
<th>Drip/Micro</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Corn</td>
<td>87.1</td>
<td>0.8</td>
<td>0.0</td>
<td>12.1</td>
</tr>
<tr>
<td>2 Cotton</td>
<td>93.9</td>
<td>5.1</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>3 Dry beans</td>
<td>56.9</td>
<td>43.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4 Grains</td>
<td>87.3</td>
<td>10.5</td>
<td>0.0</td>
<td>2.2</td>
</tr>
<tr>
<td>5 Safflower</td>
<td>57.6</td>
<td>27.8</td>
<td>0.0</td>
<td>14.6</td>
</tr>
<tr>
<td>6 Sugar beet</td>
<td>99.9</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>7 Other Field crops</td>
<td>85.1</td>
<td>12.9</td>
<td>1.7</td>
<td>0.3</td>
</tr>
<tr>
<td>8 Alfalfa</td>
<td>80.3</td>
<td>17.4</td>
<td>0.0</td>
<td>2.2</td>
</tr>
<tr>
<td>9 Pasture</td>
<td>75.1</td>
<td>20.2</td>
<td>0.0</td>
<td>4.7</td>
</tr>
<tr>
<td>10 Onion &amp; Garlic</td>
<td>43.7</td>
<td>56.3</td>
<td>0.1</td>
<td>0.0</td>
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<tr>
<td>11 Potato</td>
<td>1.2</td>
<td>91.2</td>
<td>7.6</td>
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</tr>
<tr>
<td>12 Tomato (fresh)</td>
<td>61.3</td>
<td>0.0</td>
<td>38.7</td>
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<tr>
<td>13 Tomato (process)</td>
<td>67.8</td>
<td>30.2</td>
<td>2.0</td>
<td>0.0</td>
</tr>
<tr>
<td>14 Other Truck Crops</td>
<td>36.1</td>
<td>38.0</td>
<td>25.9</td>
<td>0.0</td>
</tr>
<tr>
<td>15 Almond &amp; Pistachio</td>
<td>19.2</td>
<td>11.3</td>
<td>69.3</td>
<td>0.2</td>
</tr>
<tr>
<td>16 Other Deciduous</td>
<td>33.7</td>
<td>30.8</td>
<td>35.0</td>
<td>0.4</td>
</tr>
<tr>
<td>17 Subtropical Trees</td>
<td>10.1</td>
<td>12.5</td>
<td>76.6</td>
<td>0.9</td>
</tr>
<tr>
<td>18 Turfgrass &amp; landscape</td>
<td>0.6</td>
<td>89.0</td>
<td>10.2</td>
<td>0.2</td>
</tr>
<tr>
<td>19 Vineyard</td>
<td>20.8</td>
<td>8.7</td>
<td>70.2</td>
<td>0.2</td>
</tr>
<tr>
<td>20 Total</td>
<td>49.4</td>
<td>15.6</td>
<td>33.1</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Tables 4 and 5 show the irrigated land area by each of 13 crops and by each 16 different irrigation methods in California during 1991 and 2001, respectively.
### Table 4. Statewide irrigated land (acres) by crop and irrigation method in 1991

<table>
<thead>
<tr>
<th>Irrigation Methods</th>
<th>ALF</th>
<th>SGR</th>
<th>CRN</th>
<th>CTN</th>
<th>OTH</th>
<th>PAS</th>
<th>DEC</th>
<th>SUB</th>
<th>SBT</th>
<th>TOM</th>
<th>VEG</th>
<th>VIN</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild flood</td>
<td>4,616</td>
<td>1,265</td>
<td>563</td>
<td>0</td>
<td>1,815</td>
<td>9,282</td>
<td>4,286</td>
<td>259</td>
<td>0</td>
<td>0</td>
<td>309</td>
<td>1,298</td>
<td>23,697</td>
</tr>
<tr>
<td>Border</td>
<td>49,793</td>
<td>23,862</td>
<td>4,567</td>
<td>13,360</td>
<td>8,025</td>
<td>9,364</td>
<td>20,869</td>
<td>249</td>
<td>178</td>
<td>396</td>
<td>538</td>
<td>3,021</td>
<td>133,983</td>
</tr>
<tr>
<td>Basin</td>
<td>566</td>
<td>452</td>
<td>35</td>
<td>0</td>
<td>1,944</td>
<td>165</td>
<td>981</td>
<td>558</td>
<td>0</td>
<td>0</td>
<td>151</td>
<td>781</td>
<td>5,832</td>
</tr>
<tr>
<td>Furrow</td>
<td>4,362</td>
<td>8,717</td>
<td>11,313</td>
<td>40,451</td>
<td>8,983</td>
<td>2,626</td>
<td>12,911</td>
<td>3,238</td>
<td>8,630</td>
<td>13,318</td>
<td>13,135</td>
<td>17,409</td>
<td>145,093</td>
</tr>
<tr>
<td>Furrow and wheel line</td>
<td>0</td>
<td>168</td>
<td>44</td>
<td>400</td>
<td>353</td>
<td>0</td>
<td>417</td>
<td>0</td>
<td>781</td>
<td>1,650</td>
<td>2,141</td>
<td>469</td>
<td>6,424</td>
</tr>
<tr>
<td>Furrow and hand move</td>
<td>0</td>
<td>1,929</td>
<td>1,359</td>
<td>11,784</td>
<td>721</td>
<td>158</td>
<td>1,077</td>
<td>235</td>
<td>1,420</td>
<td>16,934</td>
<td>10,260</td>
<td>477</td>
<td>46,354</td>
</tr>
<tr>
<td>Solid set sprinkler</td>
<td>44</td>
<td>0</td>
<td>0</td>
<td>469</td>
<td>689</td>
<td>504</td>
<td>28,546</td>
<td>3,460</td>
<td>116</td>
<td>74</td>
<td>8,141</td>
<td>6,210</td>
<td>48,254</td>
</tr>
<tr>
<td>Hand move sprinkler</td>
<td>3,162</td>
<td>1,855</td>
<td>0</td>
<td>3,848</td>
<td>412</td>
<td>1,998</td>
<td>8,028</td>
<td>291</td>
<td>1,566</td>
<td>1,492</td>
<td>3,604</td>
<td>277</td>
<td>26,533</td>
</tr>
<tr>
<td>Linear move sprinkler</td>
<td>0</td>
<td>99</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>44</td>
<td>121</td>
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<td>0</td>
<td>0</td>
<td>2,438</td>
<td>0</td>
<td>2,742</td>
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<tr>
<td>Wheel line sprinkler</td>
<td>2,974</td>
<td>2,035</td>
<td>0</td>
<td>0</td>
<td>1,089</td>
<td>175</td>
<td>7</td>
<td>242</td>
<td>0</td>
<td>689</td>
<td>0</td>
<td>0</td>
<td>7,212</td>
</tr>
<tr>
<td>Micro and mini sprinkler</td>
<td>299</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>42</td>
<td>0</td>
<td>9,327</td>
<td>25,416</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>37</td>
<td>35,123</td>
</tr>
<tr>
<td>Hose pull sprinkler</td>
<td>516</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>170</td>
<td>2,388</td>
<td>2,065</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>89</td>
<td>5,229</td>
</tr>
<tr>
<td>Other sprinkler methods</td>
<td>1,988</td>
<td>299</td>
<td>0</td>
<td>249</td>
<td>133</td>
<td>274</td>
<td>442</td>
<td>170</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,567</td>
</tr>
<tr>
<td>Surface drip</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>0</td>
<td>8,687</td>
<td>2,947</td>
<td>0</td>
<td>0</td>
<td>2,719</td>
<td>21,610</td>
<td>36,010</td>
</tr>
<tr>
<td>Burried drip</td>
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<td>0</td>
<td>0</td>
<td>161</td>
<td>168</td>
<td>0</td>
<td>3,762</td>
<td>143</td>
<td>0</td>
<td>299</td>
<td>4,182</td>
<td>299</td>
<td>9,013</td>
</tr>
<tr>
<td>Drip and sprinkler</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,210</td>
<td>22</td>
<td>0</td>
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<td>499</td>
<td>153</td>
<td>1,885</td>
</tr>
<tr>
<td>Subsurface total</td>
<td>650</td>
<td>165</td>
<td>161</td>
<td>0</td>
<td>121</td>
<td>1,630</td>
<td>267</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>141</td>
<td>3,125</td>
</tr>
<tr>
<td>Total</td>
<td>69,004</td>
<td>39,646</td>
<td>18,061</td>
<td>70,724</td>
<td>25,520</td>
<td>26,392</td>
<td>103,318</td>
<td>39,337</td>
<td>12,691</td>
<td>34,792</td>
<td>48,121</td>
<td>52,270</td>
<td>539,875</td>
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</table>
Table 5. Statewide irrigated land (acres) by crop and irrigation method in 2001

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>ALF</th>
<th>SGR</th>
<th>CRN</th>
<th>CTN</th>
<th>OTH</th>
<th>PAS</th>
<th>DEC</th>
<th>SUB</th>
<th>SBT</th>
<th>TOM</th>
<th>VEG</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBSURFACE</td>
<td>1,545</td>
<td>583</td>
<td>4,183</td>
<td>381</td>
<td>339</td>
<td>1,505</td>
<td>316</td>
<td>358</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>WILD FLOOD</td>
<td>1,279</td>
<td>1,926</td>
<td>1,843</td>
<td>0</td>
<td>479</td>
<td>11,119</td>
<td>2,941</td>
<td>169</td>
<td>0</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td>BORDER</td>
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<td>17,505</td>
<td>4,672</td>
<td>700</td>
<td>3,741</td>
<td>10,255</td>
<td>14,506</td>
<td>216</td>
<td>0</td>
<td>0</td>
<td>84</td>
</tr>
<tr>
<td>BASIN</td>
<td>225</td>
<td>70</td>
<td>65</td>
<td>0</td>
<td>205</td>
<td>242</td>
<td>1,836</td>
<td>1,103</td>
<td>0</td>
<td>0</td>
<td>149</td>
</tr>
<tr>
<td>FURROW</td>
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<td>3,360</td>
<td>23,093</td>
<td>32,456</td>
<td>4,692</td>
<td>849</td>
<td>6,552</td>
<td>2,288</td>
<td>1,708</td>
<td>5,635</td>
<td>7,343</td>
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<td>72</td>
<td>0</td>
<td>2,000</td>
<td>0</td>
<td>1,120</td>
<td>212</td>
<td>112</td>
<td>0</td>
<td>0</td>
<td>800</td>
</tr>
<tr>
<td>HAND- MOVE</td>
<td>469</td>
<td>148</td>
<td>341</td>
<td>100</td>
<td>385</td>
<td>321</td>
<td>1,847</td>
<td>102</td>
<td>0</td>
<td>2,881</td>
<td>8,097</td>
</tr>
<tr>
<td>PERMANENT</td>
<td>47</td>
<td>80</td>
<td>50</td>
<td>652</td>
<td>15</td>
<td>859</td>
<td>15,883</td>
<td>3,627</td>
<td>0</td>
<td>2</td>
<td>1,147</td>
</tr>
<tr>
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<td>1,403</td>
<td>2</td>
<td>1,265</td>
<td>2,050</td>
<td>2,538</td>
<td>3,308</td>
<td>368</td>
<td>0</td>
<td>2,299</td>
<td>17,02</td>
</tr>
<tr>
<td>LINEAR-MOVE</td>
<td>2,345</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>2,025</td>
<td>80</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>SIDE-ROLL</td>
<td>4,323</td>
<td>715</td>
<td>0</td>
<td>0</td>
<td>292</td>
<td>580</td>
<td>89</td>
<td>464</td>
<td>0</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>MICRO-MINI</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>40,019</td>
<td>25,388</td>
<td>0</td>
<td>0</td>
<td>245</td>
</tr>
<tr>
<td>HOSE-PULL</td>
<td>40</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>203</td>
<td>1,047</td>
<td>423</td>
<td>0</td>
<td>0</td>
<td>105</td>
</tr>
<tr>
<td>CENTER - PIVOT</td>
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<td>220</td>
<td>0</td>
<td>525</td>
<td>224</td>
<td>100</td>
<td>57</td>
<td>0</td>
<td>0</td>
<td>412</td>
</tr>
<tr>
<td>ABOVE GROUND</td>
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<td>0</td>
<td>122</td>
<td>0</td>
<td>25,874</td>
<td>4,379</td>
<td>0</td>
<td>477</td>
<td>6,779</td>
</tr>
<tr>
<td>BURIED DRIP</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2,447</td>
<td>604</td>
<td>2</td>
<td>2,290</td>
<td>2,556</td>
</tr>
<tr>
<td>Total</td>
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<td>26,452</td>
<td>34,470</td>
<td>37,554</td>
<td>12,857</td>
<td>31,839</td>
<td>117,056</td>
<td>39,683</td>
<td>1,710</td>
<td>14,383</td>
<td>44,01</td>
</tr>
</tbody>
</table>

Survey of Irrigation Methods in California  
Volume 4
Irrigation Methods

Irrigation methods are separated into four groups, surface (gravity), sprinkler, drip/micro, and subsurface. These types of irrigation methods are used by growers to irrigate their crops in the state.

Sub-Surface Irrigation

In sub-surface irrigation, underground pipe or open ditches are blocked to back up water and force it into a crop root zone.

Surface Irrigation

Surface irrigation includes wild flood, border, basin, furrow irrigation without sprinklers, wheel line sprinklers followed by furrow irrigation, and hand move sprinklers followed by furrow irrigation. Acres that are irrigated with both sprinklers and furrows are included under the surface irrigation column.

Sprinkler Irrigation

Sprinkler methods include solid set, hand move, linear move, wheel line, hose pull, and other types including center pivot, gun-type, etc.

Drip/Micro-Sprinkler Irrigation

Drip/micro-sprinkler irrigation includes surface and buried and micro- or mini-sprinklers.

The method used to separate irrigation methods into four groups in 2001 is slightly different from those used in 1991 study. Micro- or mini sprinklers are combined with surface and buried drip in 2001, while they were listed as sprinklers in 1991 study. To be consistent with 2001 estimates, micro sprinklers in 1991 were separated into surface and buried drip as done in 2001. Table 6 and 7 show the breakdown of irrigated land in percentage by each of 13 crops and four irrigation methods during 1991 and 2001.

Table 6. Percentage of irrigated land planted by crop and irrigation method in 1991

<table>
<thead>
<tr>
<th>Irrigation Method</th>
<th>ALF</th>
<th>SGR</th>
<th>CRN</th>
<th>CTN</th>
<th>OTH</th>
<th>PAS</th>
<th>DEC</th>
<th>SUB</th>
<th>SBT</th>
<th>TOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity</td>
<td>86.0</td>
<td>88.8</td>
<td>99.1</td>
<td>93.3</td>
<td>89.5</td>
<td>81.8</td>
<td>39.2</td>
<td>11.5</td>
<td>86.7</td>
<td>92.7</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>12.6</td>
<td>10.8</td>
<td>0.0</td>
<td>6.5</td>
<td>9.1</td>
<td>12.0</td>
<td>38.3</td>
<td>15.9</td>
<td>13.3</td>
<td>6.5</td>
</tr>
<tr>
<td>Low Volume</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2</td>
<td>0.9</td>
<td>0.0</td>
<td>22.2</td>
<td>72.5</td>
<td>0.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Subsurface</td>
<td>0.9</td>
<td>0.4</td>
<td>0.9</td>
<td>0.5</td>
<td>6.2</td>
<td>0.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 6. Percentage of irrigated land planted by crop and irrigation method in 1991 (continued)

<table>
<thead>
<tr>
<th>Irrigation Method</th>
<th>VEG</th>
<th>VIN</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity</td>
<td>55.1</td>
<td>44.9</td>
<td>66.9</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>29.5</td>
<td>12.6</td>
<td>17.3</td>
</tr>
<tr>
<td>Low Volume</td>
<td>15.4</td>
<td>42.3</td>
<td>15.2</td>
</tr>
<tr>
<td>Subsurface</td>
<td>0.0</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
To compare the earlier estimates with those of 2001, it was also necessary to aggregate the 1991 and 2001 crops into four crop groups. The breakdown of irrigated land in percentage by four crop groups and four irrigation methods during 1991 and 2001 are shown in Tables 8 and 9, respectively.

### Table 8. Percentages of irrigated land by four crop categories and irrigation methods in 1991

<table>
<thead>
<tr>
<th>Irrigation Method</th>
<th>Field</th>
<th>Vegetable</th>
<th>Orchard</th>
<th>Vineyard</th>
<th>All Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity</td>
<td>89.3</td>
<td>70.9</td>
<td>31.6</td>
<td>44.9</td>
<td>66.9</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>9.4</td>
<td>19.8</td>
<td>32.1</td>
<td>12.6</td>
<td>17.3</td>
</tr>
<tr>
<td>Low Volume</td>
<td>0.3</td>
<td>9.3</td>
<td>36.1</td>
<td>42.3</td>
<td>15.2</td>
</tr>
<tr>
<td>Subsurface</td>
<td>1.0</td>
<td>0.0</td>
<td>0.2</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Table 9. Percentages of irrigated land by four crop categories and irrigation methods in 2001

<table>
<thead>
<tr>
<th>Irrigation Method</th>
<th>Field</th>
<th>Vegetable</th>
<th>Orchard</th>
<th>Vineyard</th>
<th>All Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity</td>
<td>83.6</td>
<td>42.9</td>
<td>20.3</td>
<td>20.8</td>
<td>49.6</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>12.3</td>
<td>36.0</td>
<td>16.2</td>
<td>8.7</td>
<td>15.7</td>
</tr>
<tr>
<td>Low Volume</td>
<td>0.1</td>
<td>21.1</td>
<td>63.0</td>
<td>70.2</td>
<td>32.9</td>
</tr>
<tr>
<td>Subsurface</td>
<td>4.0</td>
<td>0.0</td>
<td>0.4</td>
<td>0.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Results and Discussion

A comparison of early studies with those conducted in 2001 indicated that irrigated land planted to vineyards and orchards has increased, while the percentage of land planted by field crops has decreased. Table 10 and figure 2 illustrate the estimated irrigated land in percentage by four crop categories in California since 1972 and how the percentage of acreages planted by various crop categories has changed from 1972 to 2001.


<table>
<thead>
<tr>
<th>Year</th>
<th>Field crops (%)</th>
<th>Vegetable (%)</th>
<th>Orchard (%)</th>
<th>Vineyard (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>42</td>
<td>11</td>
<td>31</td>
<td>16</td>
<td>100</td>
</tr>
<tr>
<td>1991</td>
<td>49</td>
<td>15</td>
<td>26</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>1980</td>
<td>68</td>
<td>10</td>
<td>15</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>1972</td>
<td>67</td>
<td>12</td>
<td>15</td>
<td>6</td>
<td>100</td>
</tr>
</tbody>
</table>
As it is evident from the table and figure, the percentage of land area planted to orchard has increased from about 15% to 31% and acreages planted by vineyard has increased from about 6% to 16%, while the amount of land planted by field crops has decreased from about 67% to 42% since 1972.

To validate the information of the irrigation survey conducted in 2001, we compared 2001 estimates to the 1972, 1980, and 1991 estimates to see if a shift toward drip/micro irrigation method is a positive trend for orchards and vineyards. To increase the benefits from more precise water application to soils for crop use, it is expected to see a shift from sprinkler and gravity irrigation toward drip/micro by growers. Drip/micro irrigation allows growers to distribute water more uniformly within the intended root zone than sprinkler and gravity irrigation.

Table 11 shows the percentage of irrigated land by irrigation methods for 1972, 1980, 1991, and 2001. We used the information in Table 11 to see if there is a consistent trend in shifting irrigation methods from gravity to drip/micro between 1972 and 2001. The results confirm the trend of decreased acreage in gravity and the increased acreage in drip/micro irrigation from 1972 to 2001. The comparison demonstrates that the amount of land irrigated by gravity irrigation has declined from 80.5% in 1972 to about 49.6% in 2001, while the amount of land irrigated by micro/drip irrigation has increased from 0.3% to 32.9% over the period of the data sets. Although different methodologies were used to conduct these studies, results show a very consistent trend in the use of specific irrigation methods when plotted on a time series graph (Figure 3).
Since the 1972 and 1980 surveys were mainly based on farm advisors estimates rather than direct grower responses, there was no information available on data variability to determine changes in the use of irrigation methods. Using data from the seven surveys, non-linear trendlines of the percentage of land versus time were determined to evaluate changes in the usage of the irrigation methods from 1972 to 2001. Figure 3 shows the percentage of irrigated land by irrigation methods versus time and it shows trends in irrigation methods based on the information collected from variety of sources (e.g., decreasing use of gravity irrigation and increasing use of drip/micro irrigation). The results of this analysis confirm that the irrigation method survey conducted during 2001 is valid and reliable for long-range water planning in California.

Figure 3. Comparison of irrigated land by different irrigation method in percentage within the state
While there has been a slight decrease in acreage irrigated with sprinklers, there has been a shift towards more irrigated acreage with drip/micro irrigation in 2001. The decrease in sprinkler irrigation method in 2001 was mainly due to changes in orchard and vineyards irrigation technology, shifting from sprinklers to drip/micro irrigation. For vineyards and orchards, the amount of land irrigated by gravity and sprinkler irrigation has declined, while the amount of land irrigated by drip/micro irrigation has increased.

Figures 4-6 display the changes in irrigation method by four crop categories for 1972, 1980, 1991, and 2001 surveys. In the analysis of the 2001 survey, it was observed that gravity-driven surface irrigation methods were used to irrigate 83.5% of the field crops with an additional 12.4% irrigated by sprinkler methods. For the orchard crops, 63% were irrigated by drip irrigation methods and 20.3% irrigated using surface methods. Most of the vegetable crops were irrigated by gravity methods (42%) and 36% were irrigated by sprinkler methods. The majority of the vineyard crop land was irrigated by drip irrigation (70%) whereas 21% was irrigated by surface irrigation methods. The largest change in irrigation methods from 1972 to 2001 was the increase in drip irrigation, particularly in vineyard and orchard crops (Figure 4). In 1972, 0.6% of the vineyard crops and 1.9% of the orchard crops were under drip irrigation. In 2001, 70.2% of the vineyards and 63% of the orchards were irrigated with drip irrigation methods, an increase of 69.9% for vineyards and 61.1% for orchards. The increase in drip irrigation in vineyards corresponds with declines in both surface (down 62.6%) and sprinkler (down 7.1%) methods from 1972 to 2001. Drip irrigation also increased 21% in vegetable and 1.8% in orchard crops as well. For all crops combined, drip irrigation increased from 0.3% in 1972 to 15.2% in 1991 to 32.9% in 2001. Figure 4 illustrates the increase in drip irrigation in vegetable, orchard, and grape crops.

There has been a large increase in sprinkler irrigation with vegetable crops. Sprinkler irrigation increased from 16.9% in 1972 to 36.2% in 2001, while sprinkler use in most crops appeared to have declined slightly from 1972 to 2001. It declined dramatically in orchards from 59.3% in 1972 to 20.3% in 2001, a decrease of 39%. The large increase in sprinkler use in vegetables corresponds with declines in surface methods from 1991 to 2001, a decrease of 39.7%. Sprinkler irrigation increased 26.4% in vegetables since 1991. For all crops combined, sprinkler use decreased from 18.1% in 1972 to 17.3% in 1991 to a low of 15.7% in 2001 (Fig. 5). It is important to note that the reduction in sprinklers in 2001 was due to a shift from sprinklers to drip because of changes in orchard and grapevine irrigation practices.
Figure 4. Comparison of irrigated land by micro/drip irrigation by various crops from 1972, 1980, 1991, and 2001

<table>
<thead>
<tr>
<th>Year</th>
<th>Field Crops</th>
<th>Vegetable</th>
<th>Orchard</th>
<th>Vineyard</th>
<th>All Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>9.0</td>
<td>0.0</td>
<td>1.9</td>
<td>6.6</td>
<td>0.3</td>
</tr>
<tr>
<td>1980</td>
<td>0.3</td>
<td>2.1</td>
<td>10.0</td>
<td>10.4</td>
<td>2.4</td>
</tr>
<tr>
<td>1991</td>
<td>0.3</td>
<td>9.3</td>
<td>36.1</td>
<td>42.3</td>
<td>15.2</td>
</tr>
<tr>
<td>2001</td>
<td>6.1</td>
<td>21.1</td>
<td>63.0</td>
<td>70.2</td>
<td>32.9</td>
</tr>
</tbody>
</table>

Figure 5. Comparison of irrigated land by high-pressure sprinkler irrigation by various crops from 1972, 1980, 1991, and 2001

<table>
<thead>
<tr>
<th>Year</th>
<th>Field Crops</th>
<th>Vegetable</th>
<th>Orchard</th>
<th>Vineyard</th>
<th>All Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>13.9</td>
<td>19.8</td>
<td>37.3</td>
<td>20.0</td>
<td>10.7</td>
</tr>
<tr>
<td>1980</td>
<td>16.4</td>
<td>19.8</td>
<td>37.3</td>
<td>20.0</td>
<td>10.7</td>
</tr>
<tr>
<td>1991</td>
<td>9.4</td>
<td>19.8</td>
<td>32.1</td>
<td>12.6</td>
<td>17.3</td>
</tr>
<tr>
<td>2001</td>
<td>12.3</td>
<td>39.0</td>
<td>16.2</td>
<td>8.7</td>
<td>15.7</td>
</tr>
</tbody>
</table>
The results from comparing the surveys conducted in 1972, 1980, 1991, and 2001, show that surface irrigation has declined for all crops from 80.5% in 1972 to 49.6% in 2001 (Figure 6). There has been a dramatic decrease particularly in vineyards. In 1972, approximately 82.5% of the land area planted to vegetables, 59.3% planted to orchards, and 83.6% planted to vineyards were under surface irrigation methods. In 2001, 42.8% of the vegetables, 20.3% of the orchards, and 20.8% vineyards were irrigated with surface irrigation methods. The study shows a decrease of 39.7% for vegetables, 39% for orchards, and 62.8% for vineyards.

The reductions in surface methods are due to the reductions in field crop acreages. The percentage of land area planted to orchard has increased from about 15% to 31% and acreages planted by vineyard has increased from about 6% to 16%, while the amount of land planted by fields crops has decreased from about 67% to 42% since 1972.

Table 12 displays percentage change per year of percentage of acreages irrigated by gravity, sprinkler, and drip methods for four crop categories between 1972 and 2001. There has been a large increase in drip irrigation, particularly in vineyards. The table below shows that the drip irrigation in vineyards has increased at an average rate of 2.4% per year over the period of the data sets (Table 12 and Figure 7).
Table 12. Percentage change per year of percentage of land area irrigated by various irrigation methods by four crop categories assuming a linear change between 1972 and 2001.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Irrigation Method</th>
<th>Change per Year (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field crops</td>
<td>Gravity</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td>Sprinkler</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>Drip</td>
<td>0.01</td>
</tr>
<tr>
<td>Vegetable</td>
<td>Gravity</td>
<td>-1.37</td>
</tr>
<tr>
<td></td>
<td>Sprinkler</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>Drip</td>
<td>0.72</td>
</tr>
<tr>
<td>Orchard</td>
<td>Gravity</td>
<td>-1.34</td>
</tr>
<tr>
<td></td>
<td>Sprinkler</td>
<td>-0.78</td>
</tr>
<tr>
<td></td>
<td>Drip</td>
<td>2.11</td>
</tr>
<tr>
<td>Vineyard</td>
<td>Gravity</td>
<td>-2.16</td>
</tr>
<tr>
<td></td>
<td>Sprinkler</td>
<td>-0.78</td>
</tr>
<tr>
<td></td>
<td>Drip</td>
<td>2.40</td>
</tr>
<tr>
<td>All crops</td>
<td>Gravity</td>
<td>-1.07</td>
</tr>
<tr>
<td></td>
<td>Sprinkler</td>
<td>-0.08</td>
</tr>
<tr>
<td></td>
<td>Drip</td>
<td>1.12</td>
</tr>
</tbody>
</table>

There was a small increase in the use of the drip irrigation for vineyards between 1972 and 1980, an increase of 9.8%. But a dramatic increase in drip irrigation was observed between 1980 and 2001, an increase of 59.8%. The rate of increase calculated between 1980 and 2001 is about 3% per year. The increase in drip irrigation is mostly due to a 2.16% per year decrease in surface irrigation and 0.75% decrease in sprinkler to vineyards. The uses of drip irrigation in orchards and vegetable crops have also increased at about 2.1% and 1.1% per year, respectively. For all crops, drip irrigation increased at about 1.1% per year during the period of record. For vegetable crops, drip irrigation increased at a rate of 0.72% per year. Although use of sprinkler irrigation in most crops declined slightly from 1972 to 2001, it increased at about 0.67% per year for vegetable crops (Table 12 and Figure 7). For vineyard and orchard crops, surface irrigation has declined approximately 2.16% and 1.3% per year from 1972 to 2001, respectively. For vegetables and all crops, surface irrigation declined at about 1.37% and 1.07% per year, respectively. There have been no changes in irrigation methods for field crops. Results indicate that field crops are still mainly irrigated by surface irrigation methods and the land area planted to field crops is reduced by small percentage.
Conclusions

The results of 2001 survey demonstrate consistent trends in crop acreages as well as the irrigation methods used in the various crops based on the information collected from variety of sources. A decrease in use of surface irrigation and an increase in use of drip/micro irrigation have been observed. The largest increase in drip irrigation use occurred in orchards and vineyards. The largest increase in sprinkler use was in vegetable crops. The results of this survey seem to be consistent with the information collected from other sources on trends in crop acreage and irrigation methods.

References


Quantified Scenarios of 2030 California Water Demand
By David Groves, Pardee RAND Graduate School and Scott Matyac and Tom Hawkins, DWR
QUANTIFIED SCENARIOS OF 2030 CALIFORNIA WATER DEMAND

California Water Plan Update 2005

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California Department of Water Resources

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Preface

This article presents collaborative work between David Groves, a recent graduate of the Pardee RAND Graduate School (www.prsg.edu), and Scott Matyac and Tom Hawkins of the Department of Water Resources Division of Planning and Local Assistance. This work is also part of David Groves’ doctoral thesis (available at www.rand.org/Abstracts/) and was funded by a grant from the Pardee RAND Graduate School and the National Science Foundation (grant number SES-0345925).
Acronyms

BMPs  Best Management Practices
CC    Central Coast
CF    Consumed Fraction
CR    Colorado River
CT    Current Trends
CUWA  California Urban Water Agencies
CVPIA Central Valley Project Improvement Act
CWP   California Water Plan (DWR bulletin B-160)
DOF   California Department of Finance
DWR   California Department of Water Resources
ET    Evapotranspiration
ETAW  Evapotranspiration of Applied Water
HH    Household
HR    Hydrologic Region
ICA   Irrigated Crop Area
ILA   Irrigated Land Area
LRI   Less Resource Intensive
LWU   Low Water Use
ma    Million Acres
MA    Multi-cropped Area
MAF   Million Acre-feet
MF    Multi-family (as in houses)
MOU   Memorandum of Understanding
MRI   More Resource Intensive
NC    North Coast
NL    North Lahontan
NOC   Naturally Occurring Conservation
PCMR  Potential Multi-cropping Ratio
SC    South Coast
SF    San Francisco Bay and Single family (as in houses)
SJ    San Joaquin River
SL    South Lahontan
ta    Thousand Acres
TAF   Thousand Acre-feet
TL    Tulare Lake
1 Introduction

Assuring sufficient, high-quality water supplies for California over the next several decades will be a great challenge for water resource managers. As described in Volume 1 of the California Water Plan 2005 Update (DWR 2005b), urban water needs may increase significantly as California’s population grows from 36 million in 2004\(^1\) to about 50 million in 2030.\(^2\) Growing public interest in environmental protection may lead to larger environmental water allocations to protect and restore aquatic ecosystems. Adding to this challenge, the $20 billion per year California agricultural industry\(^3\) will likely continue to consume most of the State’s water supply even though its water use may decrease due to improved irrigation methods, alternative cropping patterns, rising water costs, and urbanization of agricultural lands.

California water resource planners base their management strategies and investments, in part, on forecasts of future water demand. Past California Water Plans have sought to estimate the "gap," or difference between anticipated supply and projected demand, and to develop strategies to reduce this gap. Critics have argued, however, that a single forecast of the difference between supply and demand is likely to be too inaccurate to successfully guide long-term planning. Forecasting water supply is difficult due to the influence of many uncertain and poorly understood factors (such as the effects of climate change upon surface water supplies and the degradation of the State’s aquifers due to pollution – see Volume 1, Chapter 4 of the California Water Plan 2005 Update). Forecasting the demand for water is also problematic due to uncertainty about population and economic growth; changes in water used by households, businesses, and public facilities; agricultural land use and production; the needs for irrigation; and future requirements and public desire for increased environmental protection.

The consequences of incorrectly forecasting the demand for water may become severe in coming years. As California’s developed water supply is fully allocated in all but the wettest years, societal and environmental costs could be large if future water demand exceeds planners’ expectations. At the same time, due to the large economic, social, and environmental costs of securing new water supplies, over-preparing for future water needs is equally problematic.

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\(^1\) California Department of Finance estimates California’s population in January 2004 was 36.14 million (DOF 2004a).

\(^2\) California Department of Finance estimates the 2030 population to be 48.11 million (DOF 2004b).

\(^3\) The total value of agricultural production in 2001 was $20.5 billion (Brunke et al. 2004).
1.1 Scenarios for water resources management and planning

A scenario is a narrative or quantitative description of one possible view of the future. Analysts and decision makers often construct scenarios to better understand how decisions or policies may fare under uncertainty about the future. Scenarios are typically designed to stimulate the consideration of outcomes that have previously been ignored due to limited resources for analysis or because they are viewed as unlikely or believed to be incongruent with current decisions and policies. Narrative scenario planning has been used extensively by many organizations, including the U.S. military, Royal/Dutch Shell, and utility companies (Schwartz 1996).

Computer models can also quantify scenarios to provide additional information upon which to base the evaluation of alternative policies. Quantified scenarios can serve four primary purposes. First, they can comprise a set of standard reference cases that other members of the research community may use for their particular analyses. Second, they can help characterize significant uncertainties. Third, they can serve to focus analysts and decision makers upon potential outcomes that are inconvenient, controversial, or in violation of conventional wisdom. Finally, they can be used to test the robustness of chosen policies.

Over the past several decades, water planners have also begun to recognize the value of using scenario planning and analysis. Scenarios can help water planners to better understand the implications of uncertainty and to evaluate the performance of management strategies across more objectives. California urban water management plans, for example, now include an evaluation of the water system under normal (or average) years as well as single and multi-year drought conditions. This method has helped to focus the attention of analysts and decision makers on the consequences of less frequent but important future hydrologic conditions, and has provided an important reference from which to develop more resilient water management plans.

The California Water Plan Update 2005, in contrast to earlier Water Plans, introduces a long-term analytic effort to develop several scenarios of water supply and demand and to evaluate how various water management strategies (or response packages) would perform in each. To initiate this effort, the 2005 Water Plan staff and Advisory Committee developed three narrative scenarios of future water demand in California (see Volume 1, Chapter 4). These scenarios do not reflect any new water management strategies (such as new water efficiency programs), and do not address water supplies.

It is the intention of the DWR Water Plan staff to evaluate the performance of different policies against these or other scenarios of water demand for the 2010 Water Plan. This will require a modeling infrastructure different than the traditional simulation models used to create probabilistic forecasts.
1.2 Objective of article

This article reports on the preliminary results of a collaborative project to:

(1) build a simple model to estimate scenarios of future water demand in California, and
(2) use this model to produce quantitative estimates of four water demand scenarios, three of which are designed to reflect the narrative scenarios developed for the 2005 California Water Plan.

The model provides estimates of the quantity of water demanded out to the year 2030 under specified demographic, economic, agricultural, and water management conditions. Some of these conditions are under the influence of water managers, such as the price for water, the behavior of water users, and the technical efficiency of water processing and distribution equipment. These scenarios of future water demand, therefore, should not be used solely to estimate future supply needs. Instead these scenarios should provide a starting point from which to evaluate various management options including (1) moderating water demand through demand management programs, changes in water prices, and efficiency programs and (2) increasing effective water supplies through urban water reuse facilities, groundwater reclamation, recharge, and conjunctive use, increased water storage and conveyance, and desalinization.

2 A scenario generator for future California water demand

We created a simulator that estimates plausible scenarios of urban, agricultural, and environmental water demand under specified demographic, economic, agricultural, and water management conditions for each of California’s ten hydrologic regions (Figure 1). Urban water demand includes the demand by households, the commercial and industrial sectors, and public institutions, and uses similar methods as other urban water demand models, such as IWR-MAIN (PMCL 1999). Environmental water demand reflects the amount of water that the water management system would allocate to environmental purposes. It does not necessarily reflect all environmental needs. Each scenario is based upon average current conditions that evolve over time according to scenario-specific parameters representing the major factors that are believed to influence future water demand. Scenarios are distinguished from one another by the specification of a unique set of factors representing various trends and parameters in the model.

Urban water demand is estimated by quantifying plausible trends of households, employees, persons (as a proxy for institutional water use), and the per unit demand for each from the year 2000 (an average year climatically for most of California) to 2030. Future urban water demand is then computed by multiplying these future demand units and their average water use. Agricultural water demand is estimated by specifying
future state-wide changes in irrigated land area and multi-cropping, and trends in parameters that define how much water is needed per area of crop. Changes in crop-mix are estimated through a set of rules that apportion the statewide changes to the hydrologic regions. Future environmental water demand is based upon current environmental water use (which currently is insufficient to meet all environmental needs) and a scenario-specific percentage of year 2000 unmet environmental water need. This rudimentary method is only a placeholder for a more thorough treatment of future environmental water needs and allocations. Such a treatment would need to also consider water supplies and variability (seasonal and interannual).

This approach for estimating demand is often referred to as a “top-down” modeling approach, as individual uses of water are aggregated by end-user (e.g. persons of a household, employees of a business, and users of public institutions). This method is well suited for considering how changes in the number of water users and changes in their average water use will impact future demand. Alternative “bottom-up” approaches estimate future water use by multiplying the numbers of water-using devices, such as toilets, by their technical water requirements. This approach, used recently by Gleick et al. (2003) to assess California water conservation potential in the urban sector, is particularly useful for evaluating the impact of specific technologies or water use practices and thus can establish state or region-wide water use targets.

Figure 1: California’s ten hydrologic regions.
These two approaches are complementary. Although our method does not explicitly evaluate specific water use technologies or practices, our top-down method uses aggregate water use coefficients that can reflect different levels of technical efficiency, as estimated by bottom-up studies. By varying these parameters across scenarios, our model can represent futures in which adoption of the most efficient technologies is slow and futures in which newer more-efficient technologies come on the market and are quickly adopted.

Scenarios of water demand are projections of the amount of water that would be used under specified water use conditions (such as water price, use behavior, technical efficiency, etc.), assuming unconstrained water supply. Water demand, therefore, can be influenced through policies that increase water use efficiency. Water managers not only can consider increasing water supplies to equal future water demands (subject to a margin to accommodate supply variability), but they can also implement water use efficiency programs to moderate future water demand, thus reducing the need to increase supply. Water demand scenarios, therefore, should not be used solely to estimate future supply needs. Instead water demand scenarios provide a starting point from which to evaluate various management options including (1) moderating demand through demand management programs, changes in water prices, and efficiency programs or (2) increasing effective water supplies through reuse programs, new imports, more water storage and conveyance, or desalination.

This scenario generator is purposefully simple to be transparent, easily modifiable, and readily interpretable. Although not all relevant processes are explicitly modeled, their effects are captured in aggregation. Moreover, the simplicity of design allows the generator to be informed by higher resolution models. Specifically, the California water demand scenario generator mimics the general results of detailed probabilistic water demand forecasting tools, such as IWR-MAIN and CALAG, and enables the user to quickly and interactively generate variations of the most probable forecast to visualize and understand alternative plausible outcomes. Finally, transparency and interpretation of the generator approach are enhanced through the use of a graphical modeling environment, and the overall design encourages

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4 IWR-MAIN is an urban water demand forecasting model developed and maintained by Planning and Management Consultants, Ltd. It is widely used by California planning agencies in their management activities (Planning and Management Consultants 1999). CALAG is an agricultural crop acreage model under development by DWR staff. CALAG “simulates the decisions of agricultural producers (farmers) on a regional level based on principles of economic optimization (DWR 2005a).”
collaboration by fostering communication among analysts, decision makers, and stakeholders. Figure 2 shows an example of the graphical modeling environment used in this analysis.

Figure 2: Screen-shot of the graphical interface of the water demand scenario generator. The upper left shows a portion of the influence diagram defining the relationships between population, other parameters, and the number of homes. In the lower left is a table defining the population growth rates for two regions of the state underlying the four scenarios. The graph on the right shows the statewide housing estimates for the four different scenarios. Changes to the table will lead to alternative estimates of the number of homes.

2.1 Urban demand module

2.1.1 Overview

Scenarios of urban water demand are quantified by estimating demand independently for each hydrologic region and following end-use: residential, commercial, industrial, and public/institutional. The total urban demand (UrbanDemand) for each hydrologic region (HR) and year (y) is the product of the

---

5 The California water demand scenario generator was implemented in a graphically-based computer modeling environment called Analytica™, available from Lumina Decision Systems (www.lumina.com).
number of demand units (DemandUnit) and their water use coefficients\(^6\) (UseCoefficient) summed over each demand unit-type (U), plus other uses (Other) which includes losses and intentional groundwater recharge:\(^7\)

\[
\text{UrbanDemand}_{HR,y} = \sum_{U=\text{unit}} \left( \text{DemandUnit}_{U,HR,y} \cdot \text{UseCoefficient}_{U,HR,y} \right) + \text{Other}_{HR,y} \quad (1)
\]

Table 1 lists the demand units and factors that influence the time evolution of the demand units for each end-use category.

### Table 1: Urban end-use demand categories and their demand units.

<table>
<thead>
<tr>
<th>Urban end-use category</th>
<th>Demand unit</th>
<th>Factors influencing future demand units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Single and multi-family houses</td>
<td>Population, percentage of housed population, share of house type</td>
</tr>
<tr>
<td>Commercial</td>
<td>Commercial employees</td>
<td>Population, employed fraction, share of commercial employment</td>
</tr>
<tr>
<td>Industrial</td>
<td>Industrial employees(^*)</td>
<td>Population, employed fraction, share of industrial employment</td>
</tr>
<tr>
<td>Public/institutional</td>
<td>People</td>
<td>Independent estimate</td>
</tr>
</tbody>
</table>

\(^*\) Industrial water use is largely process-driven, and using industrial employees as a proxy for industrial water use may not always be appropriate. As state-wide industrial use is a small percentage of total urban use, we chose to use employees to simply model industrial water use. More detailed studies should use process-based method for industrial water use.

#### 2.1.2 Population

Population is a primary driver of urban water demand – housing growth, employment growth, and public sector water use are all correlated with population growth.\(^8\) We model population to increase according to a scenario-specific annual growth rate for each hydrologic region (\(r\)).\(^9\) The population in region \(HR\) and year \(y\) is then:

\[
\text{Pop}_{HR,y} = \text{Pop}_{HR,2000} \cdot (1 + r_{HR})^{y-2000} \quad (2)
\]

---

\(^6\) A use coefficient is the water used by an individual demand unit per time period in units of water volume over demand unit.

\(^7\) Intentional groundwater recharge is classified as a demand in this model to conform to DWR water balance accounting. For applications in which this model is coupled to supply-based models, one should assure that groundwater recharge is not double counted.

\(^8\) We use the word correlation here because in some instances population growth leads to the construction of new homes and creation of new jobs, and in other instances, it’s the other way around; i.e., the construction of new homes and the creation of new jobs attracts new population.

\(^9\) Plausible growth rates can be informed by the results of detailed demographic models such as those used by the California Department of Finance.
2.1.3 Housing

The future stock of single-family (SF) and multi-family (MF) housing is a function of population changes, changes in the percentage of the population living in homes, the mean size of SF and MF homes, and the relative share of SF to MF homes.

The relative share of single family homes (Sfshare) in 2000 is computed from 2000 data of the numbers of single family homes (SFhomes) and multifamily homes (MFhomes):

\[ Sfshare_{IR,2000} = \frac{SFhomes_{IR,2000}}{SFhomes_{IR,2000} + MFhomes_{IR,2000}} \]  

(3)

The number of people living in permanent housing (HousedPop) in 2000 is calculated from the number of homes in 2000 and the mean household size in 2000 (SFhhsize and MFhhsize):

\[ HousedPop_{IR,2000} = SFhomes_{IR,2000} \times SFhhsize_{IR,2000} + MFhomes_{IR,2000} \times MFhhsize_{IR,2000} \]  

(4)

The share of the population living in houses (HousedPopShare) is, therefore, the housed population divided by the total population. Household size, the share of single family homes, and the housed population percentage change linearly from 2000 to 2030 by scenario-specific percentages. The number of SF homes in year \( y \) is then calculated as:

\[ SFhomes_{IR,y} = \frac{(HousedPopShare_{IR,y} \times Pop)_{IR,y}}{SFhhsize_{IR,y} + MFhhsize_{IR,y} - MFhomes_{IR,y} \times Sfshare_{IR,y}} \]  

(5)

and the number of MF homes in year \( y \) is calculated as:

\[ MFhomes_{IR,y} = \frac{SFhomes_{IR,y} \times (1 - Sfshare_{IR,y})}{Sfshare_{IR,y}} \]  

(6)

2.1.4 Employment

The number of employees in the commercial and industrial sectors for each hydrologic region is related to the population of each hydrologic region and is represented by an employment rate. The year 2000 employment rate is:

\[ EmployRate_{IR,2000} = \frac{(ComEmployees_{IR,2000} + IndustEmployees_{IR,2000})}{Pop_{IR,2000}} \]  

(7)

The employment rate changes linearly by a scenario-specific amount over the simulation period:

\[ EmployRate_{IR,y} = EmployRate_{IR,2000} + \Delta EmployRate_{IR} \cdot \frac{(y - 2000)}{(2030 - 2000)} \]  

(8)
The number of commercial employees over the total non-farm employees (CommFraction) for each hydrologic region also changes linearly over the simulation period:

\[
\text{CommFraction}_{HR,y} = \text{CommFraction}_{HR,2000} + \Delta \text{CommFraction}_{HR} \cdot \frac{(y - 2000)}{(2030 - 2000)}
\]  

(9)

The number of commercial and industrial employees in year \(y\) and hydrologic region \(HR\) is thus:

\[
\text{CommEmploy}_{HR,y} = \text{Pop}_{HR,y} \cdot \text{EmployRate}_{HR,y} \cdot \text{CommFraction}_{HR,y}
\]

(10)

and

\[
\text{IndustEmploy}_{HR,y} = \text{Pop}_{HR,y} \cdot \text{EmployRate}_{HR,y} \cdot (1 - \text{CommFraction}_{HR,y})
\]

(11)

2.1.5 Water use coefficients

Water use coefficients indicate the amount of water demanded by each demand unit.\(^{10}\) For the year 2000, they are computed directly from the DWR year 2000 water use data and demand unit data (DWR 2005c) by hydrologic region:

\[
\text{UseCoef}_{U,HR,2000} = \frac{\text{Use}_{U,HR,2000}}{\text{DemandUnit}_{U,HR,2000}}
\]

(12)

where \(U\) is the particular demand unit (e.g. house type, employee, etc.).

Over time, water use coefficients may change in response to factors such as changes in the price of water and in consumer income, improvements in the efficiency of equipment related to water use (such as toilets), and active programs designed to accelerate these equipment upgrades. These effects, however, are difficult to disentangle when estimating future water demand. For example, water price may change use behavior directly and also by prompting users to purchase more efficient equipment. Rising incomes may make users less sensitive to rising water prices, but also may increase their propensity to purchase water efficient equipment. The use coefficient captures the effects of demand management programs as well as conservation that would have occurred naturally.

In this model, water use coefficients (UseCoef) change in two ways. Changes in water price, income, and household size (for household coefficients) modify water use coefficients through elasticity factors (EFactors). All other changes are captured in a multiplicative factor (OtherEffects). Other effects include changes caused by the adoption of more efficient water-use technologies, conservation programs, behavioral

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\(^{10}\) A use coefficient is analogous or identical with the ordinary economic concept of demand and hence is just a function of all determinants of demand, including price, and other relevant factors, some of which may be direct policy variables.
changes not captured by the efficiency factors, etc.\footnote{11} The coefficient for water use in the interior of a single-family home at year $y$ and hydrologic region $HR$ ($UseCoef_{SF-int,HR,y}$), for example, is estimated as:\footnote{12}

$$UseCoef_{SF-int,HR,y} = UseCoef_{SF-int,HR,2000} \cdot EFactors_{SF-int,HR,y} \left(1 + OtherEffects_{SF-int,HR,y}\right)$$  (13)

where

$$EFactors_{SF-int,HR,y} = \left(\frac{Income_{int,y}}{Income_{int,2000}}\right)^{\gamma_{Income}} \cdot \left(\frac{Price_{int,y}}{Price_{int,2000}}\right)^{\gamma_{Price}} \cdot \left(\frac{SFsize_{int,y}}{SFsize_{int,2000}}\right)^{\gamma_{SFsize}}$$  (14)

and

$$OtherEffects_{SF-int,HR,y} = OtherEffects_{SF-int,HR} \cdot \frac{(y - 2000)}{(2030 - 2000)}$$  (15)

In Equation 14, $\gamma_{Income}$, $\gamma_{Price}$, and $\gamma_{SFsize}$ are elasticity factors that reflect water use changes in response to income, price, and single-family household size, respectively. In Equation 15, $OtherEffects$ is the total percentage change in the use coefficient due to other effects from 2000 to 2030. Table 2 indicates which parameters affect the water use coefficients for each urban end-use category.

Table 2: Relevant elasticity factors and other effects influencing each urban end-use category.

<table>
<thead>
<tr>
<th>Urban end-use category</th>
<th>Water price</th>
<th>Income</th>
<th>Household size</th>
<th>Other effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household interior</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Household exterior</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Public/Institutional</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.1.6 Losses and other water demands

The DWR includes intentional groundwater recharge and losses as two additional domestic water use categories. Our model specifies intentional groundwater recharge to remain constant at 2000 levels and for losses to remain proportional to the total use.

\[\text{Other effects, for example, could include the implementation of Best Management Practices as defined by the Memorandum of Understanding (CUWCC 2004) as well as other efficiency programs.}\]

\[\text{The equations used to estimate the effects of income, price, and household size upon water use are based on Planning and Management Consultants (1992; 1999).}\]
2.2 Agricultural demand module

2.2.1 Overview

Total agricultural water use ($AU$) can be accounted for as the sum of irrigation use ($IU$), losses, and other uses.\(^\text{13}\) By expressing losses and other uses ($LossOther\%$) as a fixed percentage of year 2000 irrigation use, the total agricultural water use for any year, $y$, and hydrologic region, $HR$, is computed as:

$$AU_{HR,y} = \frac{IU_{HR,y}}{(1 - LossOther\%)}$$

(16)

where $LossOther\% = \frac{AU_{HR,2000} - IU_{HR,2000}}{AU_{HR,2000}}$ (17)

Irrigation water use depends upon the amount of land under irrigation, the amount of multi-cropping (planting more than one crop per year on the same land), and the water use per crop per planting. We decompose total irrigation water use ($IU$) into the product of the irrigated crop area ($ICA$) for each crop type and hydrologic region and the amount of applied water ($AW$) for each acre of crop for each region.\(^\text{14}\) Statewide irrigation water use is therefore estimated as:

$$IU_y = \sum_{HR=1}^{R} \sum_{crop=1}^{C} (ICA_{crop,HR,y} \cdot AW_{crop,HR,y})$$

(18)

Irrigation water demand changes if the mix of irrigated crops change or the applied water for crops changes. The evolution of the parameters is highly uncertain and can also be influenced by land use and water management policies.

2.2.2 Agricultural land use

Agricultural land use changes over time due to (1) conversion of agricultural land to urban uses, (2) new land becoming irrigated, (3) changes in the amount of multi-cropping, and (4) changes in the crops being irrigated. An important innovation of our approach is to explicitly consider the interplay between irrigated land area and multi-crop area. The irrigated crop area ($ICA$) for each hydrologic region in year $y$ is the sum of the area of total irrigated land ($ILA$) and the area of land that is multi-cropped ($MA$):\(^\text{15}\)

\(^\text{13}\) Water applied in the agricultural sector in California is largely used for irrigation. In the year 2000, irrigation consumed over 90% of agricultural water use.

\(^\text{14}\) As described below, irrigated crop area ($ICA$) is the sum of irrigated land area ($ILA$) and area multi-cropped ($MA$ – or area planted two or more times a year).

\(^\text{15}\) For example, if 800 acres of farmland is used for a single crop of wheat and 200 acres is used to grow two crops of vegetables, then the total irrigated crop acreage would be 1,200 acres.
The irrigated crop area is also the sum of the irrigated crop area by crop type for each HR and year:

$$ICA_{HR,y} = ILA_{HR,y} + MA_{HR,y} \quad (19)$$

It is difficult to project how each component of Equations 19 and 20 will evolve over time. For this model, we adopt a rules-based procedure to disaggregate scenario-specific statewide changes in irrigated land, multi-cropped, and irrigated crop area to changes at the hydrologic region and by crop type (for ICA). This procedure has three major steps:16

1. **Calculate statewide changes in irrigated land (ILA), multi-cropped area (MA), and irrigated crop area (ICA).**

2. **Apportion statewide changes in ILA, MA, and ICA across each hydrologic region.**

3. **Calculate crop-mix changes (e.g., ICA by crop and HR).**

**Step 1: Calculate statewide changes in irrigated land**

ILA is expected to change over time as land is converted from farmland to urban areas and some new lands formerly not irrigated come into production. Land use and zoning policies may also influence this baseline conversion. We model statewide ILA to change linearly by a scenario-specific amount ($\Delta ILA$) in response to these forces:

$$ILA_{state,y} = ILA_{state,2000} \left(1 + \frac{\Delta ILA_{state}}{(y - 2000)}\right) \quad (21)$$

The area of irrigated land area that is multi-cropped, MA, changes over time from the year 2000 by a fixed amount ($\Delta MA$):

$$MA_{state,y} = MA_{state,2000} \left(1 + \frac{\Delta MA_{state}}{(y - 2000)}\right) \quad (22)$$

Finally, statewide irrigated crop area is calculated as the sum of ILA and MA.

**Step 2: Apportion statewide changes in ILA, MA, and ICA across each hydrologic region**

Most of the statewide change in ILA will occur in regions of the state that (1) have significant amounts of agricultural land area under irrigation and (2) are experiencing pressures from urbanization. In other hydrologic regions, change will be modest. In the model, therefore, the state’s hydrologic regions are

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16 These steps were developed initially by Tom Hawkins and Scott Matyac of DWR in spreadsheet form and then adopted into the scenario generator by David Groves of the Pardee RAND Graduate School.
classified as either high ILA-change or low ILA-change. Low ILA-change HRs are specified to change from the year 2000 to 2030 at a specified percentage of the change from 1995 to 2020 predicted in the 1998 Water Plan (DWR 1998). The remaining ILA change required to satisfy the statewide change estimated in Step 1 is apportioned to all other HRs equally.

Changes in MA are also unlikely to occur uniformly throughout the state. In some hydrologic regions, multi-cropping may not increase beyond current levels. In other regions, new multi-cropping may be limited. The remaining regions have considerable flexibility to accommodate substantially new amounts of multi-cropping. In this model HRs are specified as no MA-change, low MA-change, and high MA-change HRs. As with ILA changes, low MA-change HRs are assumed to change from 2000 to 2030 at a specified percentage of the change from 1995 to 2020 predicted in the 1998 Water Plan (DWR 1998). The remaining MA change required to satisfy the statewide change estimated in Step 1 is apportioned to the high-change HRs equally.

Irrigated crop area by hydrologic region is simply computed as the sum of ILA and MA for each HR for each year.

**Step 3: Calculate crop-mix changes (e.g., ICA by crop and HR)**

As ILA and MA change, the area devoted to each crop type (ICA) must change as well. This model makes several key assumptions when estimating how ICA by crop type and HR will evolve over time. The first two assumptions are related to the value of the crops that are either brought into or taken out of production:

- For most regions where ICA is calculated by the model to increase, the changes occur only for high value crops.
- For regions where ICA decreases, low value crops are assumed to decrease up to a specified percentage at which point high value crops then decrease as needed.

The next two assumptions relate to the potential multi-crop ratio (PMCR), or the amount of crop land that could be multi-cropped (e.g., that which already is used for crops that could accommodate multiple cropping):

\[
PMCR_{HR,y} = \frac{MA_{HR,y}}{\sum_{crop=1}^{\text{crops}} (ICA_{crop,HR,y} \cdot PMC_c)}
\]

---

17 For example, for the Current Trends scenario, the changes in ILA for low-ILA change HRs are equal to the predicted change through 2020 by the 1998 Water Plan.
where $PMC_{crop}$ is “1” if the crop can be multi-cropped and “0” otherwise.

The rules are specified to assure that as crops are taken in and out of production due to the first two assumptions above, the potential multi-crop ratio (PCMR) remains within a plausible range:

- If the PMCR is below a minimum threshold, then potential multi-crop crops are decreased and other crops are increased until the PMCR meets the threshold.
- If the PMCR is above a maximum threshold, then potential multi-crop crops are increased and other crops are decreased until the PMCR meets the threshold.

Table 3 classifies each crop type by its value and potential for multicropping. In general, these assumptions will shift the crop mix towards the high value crops (2nd column) and away from the low value crops (3rd column). In regions where the PMCR is high, there will be larger increases in truck crops (top row), whereas in regions where the PMCR is low, the crop area devoted to trees and vines will increase (bottom row).

<table>
<thead>
<tr>
<th>Potential multi-crops</th>
<th>High Value</th>
<th>Low Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Truck crops, Grain, corn, safflower, dry beans, other field crops</td>
<td></td>
</tr>
<tr>
<td>Permanent or non-multi-crops</td>
<td>Trees and vines, Alfalfa, rice, cotton, sugar beets, and pasture</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 summarizes this three-step procedure for estimating future agricultural land use.
Table 4: Rules for estimating future agricultural land use.

<table>
<thead>
<tr>
<th>Step</th>
<th>Parameter</th>
<th>Initial data / condition</th>
<th>Calculation</th>
<th>Final result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ILA (statewide)</td>
<td>2000 data</td>
<td>Linear trend (1)</td>
<td>2000 – 2030 estimate</td>
</tr>
<tr>
<td></td>
<td>MA (statewide)</td>
<td>2000 data</td>
<td>Linear trend (2)</td>
<td>2000 – 2030 estimate</td>
</tr>
<tr>
<td></td>
<td>ICA (statewide)</td>
<td>2000 data</td>
<td>ILA + MA</td>
<td>2000 – 2030 estimate</td>
</tr>
<tr>
<td>2</td>
<td>ICA (HR)</td>
<td>Low change HRs (3)</td>
<td>% 2020 ILA trend for current trends</td>
<td>2000 – 2030 estimate</td>
</tr>
<tr>
<td></td>
<td>High change HRs (4)</td>
<td>Remaining proportional change</td>
<td>2000 – 2030 estimate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No change HRs (5)</td>
<td>2000 data</td>
<td>2000 – 2030 estimate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low change HRs (6)</td>
<td>% 2020 MA change for current trends</td>
<td>2000 – 2030 estimate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High change HRs (7)</td>
<td>Remaining proportional change</td>
<td>2000 – 2030 estimate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ICA (HR)</td>
<td>ILA + MA</td>
<td>2000 – 2030 estimate</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ICA (crop and HR) [meeting high value crop ratio requirements]</td>
<td>Positive ICA change</td>
<td>Increase all crops by same %</td>
<td>Interim estimate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HRs w/ low value crop increases (8)</td>
<td>Increase high value crops only</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HRs w/ only high value crop increases (8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Negative ICA change</td>
<td>Reduce low value crops equally up to threshold (9). Additional reduction from high value crops</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ICA (crop and HR) [meeting multi-crop ratio requirements]</td>
<td>Potential multi-crop ratio &lt; lower threshold (10)</td>
<td>Decrease potential multi-crops and increase other crops to meet lower multi-crop ratio threshold</td>
<td>2000 – 2030 estimate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potential multi-crop ratio &gt; upper threshold (11)</td>
<td>Increase potential multi-crops and decrease other non-permanent crops to meet upper multi-crop ratio threshold</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Others</td>
<td>No adjustment</td>
<td></td>
</tr>
</tbody>
</table>

() indicates factor that can vary across scenarios.
2.2.3 Applied water

Applied water meets the evapotranspiration requirements of the crop (ETAW) and other beneficial needs such as salt leaching and frost control. Some applied water is also non-beneficial. Applied water (AW) can be characterized in terms of evapotranspiration of applied water (ETAW) and the fraction of applied water consumed by the crop (CF):¹⁹

\[ AW_{\text{crop,HR}} = \frac{ETAW_{\text{crop,HR}}}{CF_{\text{crop,HR}}} \]  

A CF of 1 implies that all applied water satisfied ETAW and that no other beneficial or non-beneficial uses existed. Under actual conditions, however, CF varies between about 55% (rice grown in the Sacramento River region) to a bit over 80% (processed tomatoes). The consumed fraction of many crops can increase by reducing the non-beneficial portion of applied water through the deployment of more sophisticated irrigation technology and use of more advanced irrigation management practices.²⁰

ETAW is the difference between the plant’s natural evapotranspiration (ET) and effective precipitation (EP):

\[ ETAW_{\text{crop,HR}} = ET_{\text{crop,HR}} - EP_{\text{crop,HR}} \]  

Effective precipitation is the amount of precipitation that is stored in the soil and is available to satisfy crop needs and is largely a function of the region’s rainfall, soil conditions, and plant rooting depth.

Evapotranspiration varies by crop and growing condition and may be reduced by improving irrigation methods (by decreasing non-productive evaporation) and may be increased when yields are increased.

Until recently, it was assumed that evapotranspiration for a specific crop under specific growing conditions could not be changed. Some evidence suggests that evapotranspiration may increase, within limits, if new cultural practices or higher-yield crop varieties are used (Hsiao and Xu 2000). Evapotranspiration may also decrease as more efficient irrigation practices are used. These yield effects are modeled by an elasticity

¹⁸ Evapotranspiration of applied water (ETAW) is the amount of applied water that transpires from plant leaves and that evaporates from the soil surface.

¹⁹ Note that consumed fraction is the portion of applied irrigation water that satisfies crop evapotranspiration, as used in the 2005 Water Plan.

²⁰ For regions where non-consumed water flows back to usable aquifers and surface rivers or streams, improvements in the consumed fraction does not actually increase the water supply, although this saved water could be reapplied to other non-consumptive uses without needing to expand the water supply.
factor ($f_{yield}$), and the practice effects are modeled by a factor ($\Delta ET_{practice}$) that changes linearly over the simulation period:

$$ET_{\text{crop,HR,y}} = ET_{\text{crop,HR,2000}} \left( \frac{Yield_{\text{crop,HR,y}}}{Yield_{\text{crop,HR,2000}}} \right)^{f_{yield}} \left( 1 + \Delta ET_{\text{practice}} \frac{y - 2000}{2030 - 2000} \right)$$

(26)

Yield changes linearly by a scenario-specific percentage from 2000 to 2030.

Effective precipitation can vary linearly from 2000 to 2030 by a scenario-specific percentage to simulate long-term variability caused, for example, by climate change.

The consumed fraction of a particular crop is influenced primarily by irrigation practices and technology. We assume that increasing water price will provide incentives to farmers to use irrigation practices that increase the consumed fraction and decrease the required applied water. This effect is captured by a water price elasticity factor ($f_{price}$). Investments in irrigation technology also affect the consumed fraction linearly by a scenario-specific percentage ($\Delta CF_{tech}$). Consumed fraction by crop, HR, and year therefore is:

$$CF_{\text{crop,HR,y}} = CF_{\text{crop,HR,2000}} \left( \frac{\text{WaterPrice}_{\text{HR,y}}}{\text{WaterPrice}_{\text{HR,2000}}} \right)^{f_{price}} \left( 1 + \Delta CF_{\text{tech,HR,2000}} \frac{y - 2000}{2030 - 2000} \right)$$

(27)

2.2.4 Irrigation water use

All together, we estimate future water use for irrigation ($IU$) in year $y$ using the following formula:

$$IU_y = \sum_{HR=1}^{n} \sum_{crop=1}^{c} ICA_{\text{crop,HR,y}} \left( \frac{ET_{\text{crop,HR,y}} - EP_{\text{crop,HR,y}}}{CF_{\text{crop,HR,y}}} \right)$$

(28)

2.3 Environmental demand module

Environmental water use is classified by the Department of Water Resources as the amount of water purposefully permitted to flow through natural river channels and wetlands, instead of being diverted and used for urban or agricultural purposes. As described extensively in Volumes 1 and 3 of the 2005 Water Plan, these allocations are not always sufficient to meet the ecological objectives of the state’s aquatic ecosystems. An important objective of future California water management is to improve the health of such ecosystems, in part, by meeting legal mandates and effectively increasing environmental flow allocations.

The amount of water needed for such environmental use varies considerably with the level of precipitation and runoff in the state. It is difficult, therefore, to evaluate independently water source and

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21 The equation used to estimate the effect of yield upon crop evapotranspiration is based on reports by Planning and Management Consultants, Ltd. (1992; 1999)
supply estimates. For purposes of quantifying scenarios of total water demand independently of source and supply estimates, the model specifies future environmental water demand to be the quantity used in the year 2000 (an average year) plus a scenario-specific additional amount by region. Scenarios in which water managers’ commitment to meet environmental needs are high are specified to have greater environmental water demand.

3 Quantified scenarios of 2030 water demand

In this section we describe the model parameter values used to quantify a set of water demand scenarios for California.22

The first three scenarios are intended to represent those described in Volume 1 of the 2005 California Water Plan. The fourth scenario was developed by the authors. The model parameter values that specify each scenario were selected by the authors with consultation by other DWR staff. Note that these demand scenarios all assume that water management practices will stay as they are now and that none of the 25 response packages described in Volume 2 of the Water Plan are implemented.

The Water Plan scenarios are summarized as:

**Current Trends**: Water demand based on “current trends with no big surprises.”

**Less Resource Intensive**: “California is more efficient in 2030 water use than today while growing its economy within much more environmentally protective policies.”

**More Resource Intensive**: “California is highly productive in its economic sector. Its environment, while still important, is not the state’s first priority for water management decisions. Water use in this scenario is less efficient in 2030 than it is in [the other] scenarios…” (DWR 2005b)

The three scenarios, in general, are distinguished from each other by the intensity of resource use. In this context, resource use pertains primarily to urban development. A resource intensive future, in this case, would be one in which urban development patterns were diffuse and land plots were large. This type of development pattern would use more energy and building materials, and it would require more development of agricultural and wild landscapes.

---

22 These water demand scenarios indicate the amount of water that would be demanded at the scenario-specific water price (for the urban and agricultural sectors). Therefore, they technically are scenarios of water quantity demand (water demand implies the relationship between use and price).
These scenarios provide a good starting point or baseline from which to evaluate water management response packages. They also signal an important evolution in DWR’s treatment of uncertainty in their water demand and supply forecasts. A few concerns arise, however. First, these scenarios are difficult to interpret, as a key driver, population, is specified to be constant for the first two scenarios but greater in the third. This lack of parity has lead to considerable confusion in their interpretation. Also, as shown in the results section, future water demand for agriculture in the Less Resource Intensive scenario is greater than the demand in the Current Trends scenario. Therefore, they likely do not capture the full range of water demand. We thus include an additional scenario to represent the lower-range of plausible future water demand:

**Low Water Demand**: Water demand is lower in the urban and agricultural sectors due to slower population growth coupled with increasing conservation and low-water use economic development. The agricultural sector becomes more water efficient than expected, the conversion of land away from agriculture slows, and the shift towards more intensive agriculture is more moderate than in the other scenarios. Finally, lower demand in the urban and agricultural sectors leads to more public pressure for greater allocations to the environment.

Table 5, adapted by a table developed by DWR staff, describes how factors impacting water supply and demand might evolve from 2000 to 2030 in each scenario. In the Current Trends scenario, population is specified to evolve according to California State Department of Finance (DOF) forecasts, whereas trends in economic activity, agricultural use, and ecosystem maintenance (environmental factors) are not explicitly defined. Many factors for the other three scenarios are described as modifications to the Current Trends factors.

The urban demand factors specified in Table 5 suggest that urban water demand will be greatest for the More Resource Intensive scenario and lowest for the Low Water Demand scenario. Agricultural demand changes are less clear. Under the Current Trends scenario, the total crop area in California would decrease the most, whereas in the Less Resource Intensive scenario, crop area is specified to remain constant. This alone would lead to greater agricultural water demand in the Less Resource Intensive scenario than in the Current Trends scenario. However, total crop water use is specified to be greater in the More Resource Intensive scenario than the Current Trends scenario. As a result, the direction of agricultural water demand changes under the More Resource Intensive and Less Resource Intensive scenarios are ambiguous in the narrative. Agricultural water demand changes under the Low Water Use scenario will be lower, as in the Current Trends scenario. Finally, 2030 environmental water demand will be greater for the Less Resource Intensive and Low
Water Use scenarios (high environmental protection) and lowest for the More Resource Intensive scenario (year 2000 level of use). Table 14 shows how the demand factors for the Water Plan scenarios listed in Table 5 are quantified in the model to produce numerical scenarios of water demand.

To help understand the components of each scenario, Table 6 characterizes each scenario by sector and major influencing factor. For example, scenarios of urban water demand are distinguished by their demographic trends and water use efficiency trends. The table also presents symbolic representations of these factors for use in the results section.
Table 5: Notional descriptions of factors affecting regional and statewide water demand and for the three 2005 California Water Plan scenarios (Current Trends, Less Resource Intensive, and More Resource Intensive) and a fourth scenario (Low Water Demand). Adapted from DWR (2005b).

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>SCENARIO 1</th>
<th>SCENARIO 2</th>
<th>SCENARIO 3</th>
<th>SCENARIO 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Trends</td>
<td>Less Resource Intensive</td>
<td>More Resource Intensive</td>
<td>Low Water Demand</td>
</tr>
<tr>
<td>Total population</td>
<td>DOF</td>
<td>DOF</td>
<td>Higher than DOF</td>
<td>Lower than DOF</td>
</tr>
<tr>
<td>Population density</td>
<td>DOF</td>
<td>Higher than DOF</td>
<td>Lower than DOF</td>
<td>Higher than DOF</td>
</tr>
<tr>
<td>Population distribution</td>
<td>DOF</td>
<td>DOF</td>
<td>Higher inland and southern</td>
<td>DOF</td>
</tr>
<tr>
<td>Commercial activity</td>
<td>Current trend</td>
<td>Increase in trend</td>
<td>Increase in trend (as in 2)</td>
<td>Increase in trend (as in 2)</td>
</tr>
<tr>
<td>Commercial activity mix</td>
<td>Current trend</td>
<td>Decrease in high water use activities</td>
<td>Increase in high water use activities</td>
<td>Decrease in high water use activities</td>
</tr>
<tr>
<td>Total industrial activity</td>
<td>Current trend</td>
<td>Increase in trend</td>
<td>Increase in trend (as in 2)</td>
<td>Increase in trend</td>
</tr>
<tr>
<td>Industrial activity mix</td>
<td>Current trend</td>
<td>Decrease in high water use activities</td>
<td>Increase in high water use activities</td>
<td>Decrease in high water use activities</td>
</tr>
<tr>
<td>Crop unit water use</td>
<td>Current trend</td>
<td>Decrease in crop unit water use</td>
<td>Increase in crop unit water use</td>
<td>Decrease in crop unit water use</td>
</tr>
<tr>
<td>Environmental water-flow</td>
<td>Current trend</td>
<td>High environmental protection</td>
<td>Year 2000 level of use</td>
<td>High environmental protection</td>
</tr>
<tr>
<td>Environmental water-land</td>
<td>Current trend</td>
<td>High environmental protection</td>
<td>Year 2000 level of use</td>
<td>High environmental protection</td>
</tr>
<tr>
<td>Naturally occurring conservation</td>
<td>Naturally occurring conservation (NOC) trend in MOUs</td>
<td>Higher than NOC trend in MOUs</td>
<td>Lower than NOC trend in MOUs</td>
<td>Higher than NOC trend in MOUs</td>
</tr>
<tr>
<td>Urban water use efficiency</td>
<td>All cost effective BMPs in existing MOUs implemented by current signatories</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ag Water Use Efficiency</td>
<td>All cost effective EWMPs in existing MOUs implemented by current signatories</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per capita income</td>
<td>Current trends</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasonal/permanent crop mix</td>
<td>Current trends</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigated land retirement</td>
<td>Currently planned</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6: General characteristics of water demand scenarios by sector and factor. Symbolic representation of each scenario is shown for reference and presentation of results.

<table>
<thead>
<tr>
<th>Sector and Factors</th>
<th>Current Trends</th>
<th>Less Resource Intensive</th>
<th>More Resource Intensive</th>
<th>Low Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urban Sector</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demographics</td>
<td>Expected Growth / Expected density</td>
<td>Expected Growth / Higher density</td>
<td>Higher Growth / Lower density</td>
<td>Lower Growth / Higher density</td>
</tr>
<tr>
<td>Use Efficiency</td>
<td>Expected conservation</td>
<td>More Conservation</td>
<td>Less Conservation</td>
<td>Most conservation</td>
</tr>
<tr>
<td>Symbolic representation</td>
<td>→ growth, → density, → conservation</td>
<td>→ growth, ↑ density, ↑ conservation</td>
<td>↑ growth, ↓ density, ↓ conservation</td>
<td>↓ growth, ↑ density, ↑↑ conservation</td>
</tr>
<tr>
<td><strong>Agricultural Sector</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Use</td>
<td>Decreasing ICA / Large ILA decrease</td>
<td>Constant ICA / Small ILA decrease</td>
<td>Constant ICA / Large ILA decrease</td>
<td>Decreasing ICA / Modest ILA decrease</td>
</tr>
<tr>
<td>Crop Water Use</td>
<td>Expected reduction</td>
<td>Greater Reduction</td>
<td>Lesser reduction</td>
<td>Greatest Reduction</td>
</tr>
<tr>
<td>Symbolic representation</td>
<td>↓ ICA, ↓ ILA, ↓ CWU reduction</td>
<td>→ ICA, ↓ ILA, ↑ CWU reduction</td>
<td>→ ICA, ↓ ILA, ↓ CWU reduction</td>
<td>↓ ICA, ↓ ILA, ↑↑ CWU reduction</td>
</tr>
<tr>
<td><strong>Environmental Sector</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environ. Allocation</td>
<td>Expected allocation</td>
<td>Higher allocation</td>
<td>Lower allocation</td>
<td>Highest allocation</td>
</tr>
<tr>
<td>Symbolic representation</td>
<td>→ allocation</td>
<td>↑ allocation</td>
<td>↓ allocation</td>
<td>↑↑ allocation</td>
</tr>
</tbody>
</table>

3.1 Urban sector

3.1.1 Urban demand drivers

For the Current Trends and Less Resource Intensive scenarios we specify annual population growth to be congruent with the latest California Department of Finance (DOF) projection of 2030 population by county (DOF 2004b). For the More Resource Intensive scenario we specify the population growth rate to be 25% greater for the inland and southern HRs (South Coast, South Lahontan, Colorado River, Sacramento River, San Joaquin River, and Tulare Lake) and 16% greater for coastal and northern HRs (North Coast, San Francisco Bay, Central Coast, and North Lahontan). This roughly matches the 1998 DOF 2030 population projections (DOF 1998). For the Low Water Demand scenario, we specify total population growth to increase by 31% instead of 41% as in the DOF projections.

Housing in the Current Trends scenario is based upon DWR projections of housing (DWR 2004). The household population, share of multifamily housing, and housing size changes for the Current Trends scenario are calculated from DOF 2030 population projections (DOF 2004b), Woods and Poole 2030 population projections (Woods & Poole Economics 2004), and 1980 – 2000 U. S. censuses. The housed population is nearly constant, the share of MF housing decreases from 35.5% in 2000 to 33.9% in 2030 (as a
statewide average), and the household size decreases modestly for single and multifamily households under these scenarios.

For the Less Resource Intensive and Low Water Demand scenarios the share of multifamily housing is specified to increase 10% more than in the Current Trends scenario, and the household size increases by 0.2 persons by 2030. For the More Resource Intensive scenario, multifamily housing decreases by 5% below the Current Trends scenario, and the household size is the same as the Current Trends scenario.

The mean income (in constant dollars) for each hydrologic region is specified to increase according to recent projections from Woods and Poole Economics (2004) for all scenarios. Urban water price (in constant dollars) is specified to increase by 27.3% from 2000 to 2030 based on biennial water charge data for 1991 through 2003 from the Black & Veatch Corporation (2003) (Figure 3). Water charge represents the monthly charge incurred by a typical single family residence assuming an average monthly usage of 1,500 cubic feet of water. It does not reflect what commercial and industrial water users pay for water service.

![Graph showing trend in average urban water price from 1990 to 2030.](image)

Figure 3: Trend in 1991-2003 statewide average water charge extrapolated to estimate 2030 average water charge. Historical urban water price data obtained from the Black & Veatch Corporation (2003).

Table 7 summarizes the parameters chosen to generate the four scenarios.

---

21 Income and employment data were disaggregated by hydrologic region by Marla Hambright and Richard Le of the California Department of Water Resources.
### Table 7: Parameters for urban demand drivers for scenarios.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current Trends</th>
<th>Less Resource Intensive</th>
<th>More Resource Intensive</th>
<th>Low Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population</td>
<td>DOF trends</td>
<td>As current trends</td>
<td>DOF trends + 12%*</td>
<td>DOF trends – 10%</td>
</tr>
<tr>
<td></td>
<td>48.1 million (2030)</td>
<td></td>
<td>52.3 million (2030)</td>
<td>44.7 million (2030)</td>
</tr>
<tr>
<td>Inland and southern (SC, SL, CR, SR, SJ, TL)</td>
<td>DOF trends</td>
<td>As current trends</td>
<td>125% DOF trends</td>
<td>79% DOF trends</td>
</tr>
<tr>
<td></td>
<td>37.3 million (2030)</td>
<td></td>
<td>41.1 million (2030)</td>
<td>34.5 million (2030)</td>
</tr>
<tr>
<td>Coastal and northern (NC, SF, CC, NL)</td>
<td>DOF trends</td>
<td>As current trends</td>
<td>116% DOF trends</td>
<td>79% DOF trends</td>
</tr>
<tr>
<td></td>
<td>10.8 million (2030)</td>
<td></td>
<td>11.2 million (2030)</td>
<td>10.2 million (2030)</td>
</tr>
<tr>
<td>Housed population fraction</td>
<td>DOF trends**</td>
<td>As current trends</td>
<td>As current trends</td>
<td>As current trends</td>
</tr>
<tr>
<td>MF housing share</td>
<td>DOF trends**</td>
<td>DOF trends + 10%</td>
<td>DOF trends + 10%</td>
<td>DOF trends + 10%</td>
</tr>
<tr>
<td></td>
<td>35.5% → 33.9%***</td>
<td>35.5% → 43.9%***</td>
<td>35.5% → 28.9%***</td>
<td>35.5% → 44.0%***</td>
</tr>
<tr>
<td>SF house size</td>
<td>DOF trends**</td>
<td>DOF trends + 0.2 persons/household</td>
<td>As current trends</td>
<td>DOF trends + 0.2 persons/household</td>
</tr>
<tr>
<td></td>
<td>3.13 → 3.06***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF house size</td>
<td>DOF trends**</td>
<td>DOF Trends + 0.2 persons/household</td>
<td>As current trends</td>
<td>DOF trends + 0.2 persons/household</td>
</tr>
<tr>
<td></td>
<td>2.41 → 2.38***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean income (1996 dollars)</td>
<td>DOF trends**</td>
<td>As current trends</td>
<td>As current trends</td>
<td>As current trends</td>
</tr>
<tr>
<td></td>
<td>$87,225 → $116,269***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment fraction</td>
<td>Woods and Poole trends</td>
<td>As current trends</td>
<td>As current trends</td>
<td>As current trends</td>
</tr>
<tr>
<td></td>
<td>58% → 60%***</td>
<td>+ 2.5%</td>
<td>+ 2.5%</td>
<td>+ 2.5%</td>
</tr>
<tr>
<td>Urban water price****</td>
<td>2000 prices + 27.3%</td>
<td>As current trends</td>
<td>As current trends</td>
<td>As current trends</td>
</tr>
</tbody>
</table>

* The population 1998 DOF population trend projection (2000 to 2030) is about 11% greater than the 2004 DOF projection (51.9 million people in 2030).

** Trend varies by hydrologic region.

*** Values for 2000 → 2030.

**** Constant dollars.

#### 3.1.2 Urban demand factors

Elasticity effects for price, income, and household size vary modestly across the scenarios (Table 8).

For the Current Trends scenario, the single family price elasticity factor is derived from the 1998 Water Plan Update (DWR 1998), and multi-family price, income and household size elasticity factors are derived from a range recommended for use in the IWR-MAIN urban water demand model (Planning and Management Consultants 1999).

The Water Plan scenario narratives disaggregate water use conservation that occurs without policy intervention (called naturally occurring conservation or NOC) and through efficiency due to the continued implementation of existing Best Management Practices (BMPs) in the Memorandum of Understanding (MOU) (CUWCC 2004). Efficiency that would occur from the implementation of additional water conservation programs is not included. Recall from Section 3 above that water use coefficients in the model vary due to changes in income, water price, and household size, and other water use effects. For purposes of...
quantifying the Water Plan narrative scenarios, we assume that the naturally occurring conservation and efficiency effects are captured in the “OtherEffects” multiplicative factor described in Section 3.1.5, but are disaggregated as NOC effects and Efficiency effects, in line with the Water Plan narrative.

A&N Technical Services (2004), on behalf of California Urban Water Agencies (CUWA), estimates the total domestic conservation (termed the Gross effect) and the portion of the total conservation due solely to the implementation of a subset\(^{24}\) of BMPs (termed the Net effect).\(^{25}\) The difference between the Gross and Net effects is naturally occurring conservation (NOC). The report presents Net and Gross savings for 7 of the 10 California hydrologic regions at years 2007, 2020, and 2030. Over time, the Net savings (and therefore the Gross savings as well) decrease from 2020 to 2030 because of fixed life spans or decay rates for the BMP programs. Naturally occurring conservation increases from 2007 to 2030 and is the same for each of the three BMP implementation scenarios.

Using the data and assumptions contained in the A&N Technical Services report along with year 2000 DWR domestic water use estimates, we find that by 2030 NOC could decrease water demand by about 10% and that the effect directly attributable to the BMP could decrease water demand by about 5% of 2000 demand. We use these estimates for the Current Trends scenario (Table 8).\(^{26}\) To distinguish between the Less Resource Intensive and More Resource Intensive scenarios, we specify NOC to be -15% and -5%, respectively. We use the same NOC and Efficiency estimates for the commercial, industrial, and public sectors. In other on-going work, we derive these factors independently.

\(^{24}\) Of the 14 BMPs, only eight of them were quantified in the A&N Technical Services study.


\(^{26}\) For purposes of estimating NOC savings for households under the Current Trends 2004 Water Plan scenario, we consider the 2030 Cost Effective Implementation BMP savings over year 2000 household water use. This savings rate varies from 7% of year 2000 water use for Central Coast to about 14% in the San Joaquin River Region, excluding South Lahontan, which is above 70%. The average savings for the seven hydrologic regions is 9.8%. We use 10% as a rough estimate of total NOC for Current Trends by 2030. We apply this value equally across all hydrologic regions, despite the range of values calculated by the study. Total Net savings as a percentage of year 2000 use is estimated to be 4% for the Cost Effective scenario. For simplicity, we choose 5% for all three Water Plan scenarios, corresponding to the narrative description: “All cost effective BMPs in existing MOUs implemented by current signatories.”
Table 8: Domestic water demand factors for Water Plan scenarios.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current Trends</th>
<th>Less Resource Intensive</th>
<th>More Resource Intensive</th>
<th>Low Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price elasticity – SF [1]</td>
<td>-0.16</td>
<td>-0.35</td>
<td>-0.05</td>
<td>-0.35</td>
</tr>
<tr>
<td>Price elasticity – MF [2]</td>
<td>-0.05</td>
<td>-0.07</td>
<td>-0.03</td>
<td>-0.07</td>
</tr>
<tr>
<td>Income elasticity – SF [2]</td>
<td>0.4</td>
<td>0.2</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Income elasticity – MF [2]</td>
<td>0.45</td>
<td>0.25</td>
<td>0.65</td>
<td>0.25</td>
</tr>
<tr>
<td>HH size elasticity – SF [2]</td>
<td>0.4</td>
<td>0.2</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>HH size elasticity – MF [2]</td>
<td>0.5</td>
<td>0.3</td>
<td>0.7</td>
<td>0.3</td>
</tr>
<tr>
<td>Naturally occurring conservation – interior [3]</td>
<td>-10%</td>
<td>-15%</td>
<td>-5%</td>
<td>-15%</td>
</tr>
<tr>
<td>Naturally occurring conservation – exterior [3]</td>
<td>-10%</td>
<td>-15%</td>
<td>-5%</td>
<td>-15%</td>
</tr>
<tr>
<td>Efficiency – interior [3]</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
<tr>
<td>Efficiency – exterior [3]</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
</tbody>
</table>


Table 9 lists the commercial, industrial, and public water demand factors used for the three scenarios.

Table 9: Commercial, industrial, and public water demand factor parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current Trends</th>
<th>Less Resource Intensive</th>
<th>More Resource Intensive</th>
<th>Low Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price elasticity [1]</td>
<td>-0.085</td>
<td>-0.1</td>
<td>-0.07</td>
<td>-0.1</td>
</tr>
<tr>
<td>Naturally occurring conservation [2]</td>
<td>-10%</td>
<td>-15%</td>
<td>-5%</td>
<td>-15%</td>
</tr>
<tr>
<td>Efficiency [2]</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
</tbody>
</table>

[1] Price elasticity applies only to commercial and industrial water demand. Based on ranges of recommended values for IWR-MAIN (Planning and Management Consultants 1999).
[2] We use the same values as derived for domestic NOC and efficiency.

3.2 Agricultural sector

There are three sets of parameters used to define the scenarios of agricultural water demand, as described in Section 3: statewide agricultural land use changes, rules determining agricultural land use changes by hydrologic region and crop-type, and crop-water demand changes. The paragraphs below and Table 10 - Table 12 summarize the parameters used to represent each scenario.

Following the 2005 Water Plan’s narrative description of the Current Trends scenario, irrigated crop area is specified to decrease according to DWR forecasts based on historical rates of land conversion from agriculture to urban development, tempered by increases in multi-cropping and some new lands coming into production. See Appendix II for a detailed description of the method used to develop the Current Trends agricultural land use scenario.
The Water Plan specifies that in the Less Resource Intensive scenario, irrigated crop area levels out at the current area. To implement this in the model, we assume that irrigated land area decreases at half the rate as in the Current Trends scenario (5.6% total reduction from 2000-2030 instead of 10.0%), and the percentage of multi-cropped area increases to 11.6% in 2030. These two adjustments lead to a constant total irrigated crop area. In the More Resource Intensive scenario, irrigated crop area also levels out at the current area as in the Less Resource Intensive scenario. We specify ICA to be the same for the Low Water Demand scenario as for the Current Trends scenarios, but with a small reduction in ILA (compensated for by lesser increase in multi-cropping). Table 10 summarizes the specified trends for each agricultural land-use parameter by scenario.

Table 10: Quantification of statewide agricultural land use changes for narrative scenarios.

<table>
<thead>
<tr>
<th>Agricultural Parameter</th>
<th>Current Trends</th>
<th>Less Resource Intensive</th>
<th>More Resource Intensive</th>
<th>Low Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated crop area [1]</td>
<td>4.9% reduction (9.5 ma → 9.05 ma)</td>
<td>Constant (2000 Value - 9.5 ma)</td>
<td>Constant (2000 Value - 9.5 ma)</td>
<td>4.9% reduction (9.5 ma → 9.05 ma)</td>
</tr>
<tr>
<td>Irrigated land area [2,3]</td>
<td>10% reduction (9.0 ma → 8.1 ma)</td>
<td>5% reduction (9.0 ma → 8.5 ma)</td>
<td>10% reduction (9.0 ma → 8.1 ma)</td>
<td>7.5% reduction (9.0 ma → 8.5 ma)</td>
</tr>
<tr>
<td>Multi-cropped area [4]</td>
<td>80% increase (540 ta → 970 ta)</td>
<td>85% increase (540 ta → 890 ta)</td>
<td>165% increase (540 ta → 1,420 ta)</td>
<td>40% increase (540 ta → 752 ta)</td>
</tr>
</tbody>
</table>

[1] Changes in ICA described in narrative scenarios and computed from specified changes in ILA and MA.
[4] Changes in MA specified to produce the ICA changes shown.

Table 11 shows the parameters used to implement the rules to apportion state-water agricultural land use changes to crop changes by hydrologic region (see Section 2.2.2). The only parameters aside from the statewide trends that change across scenarios are the low value crop reduction upper limit and the potential multi-crop ration upper limit. The values shown in the table were chosen by DWR staff members as part of the development of the above mentioned rules.
Table 11: Parameters specifying agricultural land use changes by hydrologic region and crop type for each scenario. Parameter numbers refer to rules listed in Table 4.

<table>
<thead>
<tr>
<th>#</th>
<th>Parameter</th>
<th>Current Trends</th>
<th>Less Resource Intensive</th>
<th>More Resource Intensive</th>
<th>Low Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ILA statewide trend (as in Table 10)</td>
<td>-10%</td>
<td>-5%</td>
<td>-10%</td>
<td>-7.5%</td>
</tr>
<tr>
<td>2</td>
<td>MA statewide trend (as in Table 10)</td>
<td>+80%</td>
<td>+85%</td>
<td>+165%</td>
<td>+40%</td>
</tr>
<tr>
<td>3</td>
<td>Low ILA change HRs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>High ILA change HRs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>No MA change HRs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Low MA change HRs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>High MA change HRs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>HR(s) with low value crop increases</td>
<td>50%</td>
<td>50%</td>
<td>75%</td>
<td>50%</td>
</tr>
<tr>
<td>9</td>
<td>Low value crop reduction upper limit</td>
<td>2000 potential multi-crop ratio by HR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Potential Multi-crop ratio lower limit</td>
<td>36%</td>
<td>36%</td>
<td>40%</td>
<td>36%</td>
</tr>
</tbody>
</table>

Table 12 shows the parameters affecting crop water demand used for each scenario. The narrative specifies that the crop unit water use to decrease the most under the Less Resource Intensive scenario and the least under the More Resource Intensive scenario. The ET Technique and Technology CF Effects factors are specified to represent these differences. The crop water demand parameters for the Low Water Demand scenario are specified to be the same as those for the Less Resource Intensive scenario.

Agricultural water costs vary widely across geographic regions and by source of water supply (e.g., groundwater, local surface water, Central Valley Project, State Water Project). Forecasting agricultural water costs is difficult because they are often determined more by politics, legal doctrine, and tradition than on economic forces such as supply and demand. At the time of the analysis, there were no credible estimates of future California agricultural water price available, and so a conservative value was used - a modest 10% increase in real dollars for all scenarios.

A recent report by Gleick et al. (2005) proposed an alternative estimate for agricultural water price trends (+68%). This estimate is based largely on assumptions pertaining to anticipated increases in surface water rates for Central Valley Project water contractors. For this scenario exercise, however, agricultural water price changes apply to all sources of agricultural water, including State Water Project supply and groundwater. In future scenario exercises, it would be useful to vary agricultural water price across the scenarios to reflect its substantial uncertainty.
Table 12: Crop water demand parameters for each scenario.

<table>
<thead>
<tr>
<th>Agricultural Parameter</th>
<th>Current Trends</th>
<th>Less Resource Intensive</th>
<th>More Resource Intensive</th>
<th>Low Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Yield</td>
<td>2000 values*</td>
<td>110% of 2000 values</td>
<td>100% of 2000 values</td>
<td>110% of 2000</td>
</tr>
<tr>
<td>Yield-ET Elasticity</td>
<td>0.2 [1]</td>
<td>As Current Trends</td>
<td>As Current Trends</td>
<td>As Current Trends</td>
</tr>
<tr>
<td>ET Technique Factor</td>
<td>0</td>
<td>-2.5%[2]</td>
<td>0</td>
<td>-2.5%[2]</td>
</tr>
<tr>
<td>Effective Precipitation</td>
<td>2000 values</td>
<td>As Current Trends</td>
<td>As Current Trends</td>
<td>As Current Trends</td>
</tr>
<tr>
<td>Agricultural Water Price</td>
<td>110% of 2000 values</td>
<td>As Current Trends</td>
<td>As Current Trends</td>
<td>As Current Trends</td>
</tr>
<tr>
<td>Price-CF Elasticity</td>
<td>0.28 [3]</td>
<td>As Current Trends</td>
<td>As Current Trends</td>
<td>As Current Trends</td>
</tr>
<tr>
<td>Technology CF Effects</td>
<td>2.5%</td>
<td>5%</td>
<td>0%</td>
<td>5%</td>
</tr>
</tbody>
</table>

* Value varies by crop and hydrologic region. Changes are from 2000 to 2030.
[1] This effect is not well understood.

3.3 Environmental sector

Environmental Defense prepared for the California Water Plan staff a preliminary estimate of flow objectives for the year 2000 for some but not all of the major environmental objectives managed by the fisheries management agencies throughout the state (Rosekrans and Hayden 2003). These unmet objectives include the additional instream flows needed to meet the goals of CALFED’s Ecosystem Restoration Program, the objectives in the Anadromous Fisheries Restoration Program, and the additional water needed to reach the “Level 4” supplemental water supplies for National Wildlife Refuges, cited in CVPIA sections 3405 and 3406(b). A more comprehensive analysis of unmet environmental objectives would include all water legal mandates extending from the Klamath River in the north to the Salton Sea in the south and would likely result in a number much greater than the 987 MAF concluded in the Environmental Defense analysis.

We use these estimates as a starting approximation for the amount of additional water that could be allocated to the environment under various scenarios. In Table 13, we assign these additional flow requirements to their respective hydrologic region. Environmental water demands for 2030 are then specified as the sum of the 2000 environmental water use for all scenarios (39.41 MAF) and the following percentages of these unmet needs: 50% for Current Trends, 100% for Less Resource Intensive, 0% for More Resource Intensive, and 150% for Low Water Demand. For example, in the case of the Less Resource Intensive scenarios, the 2000 water use is 39.41 MAF, and 100% of the additional flow requirement is 0.987 MAF. The total 2030 environmental water "demand" therefore is 40.39 MAF.
Table 13: Partial additional flow requirements, and their respective hydrologic region (Adapted from Rosekrans and Hayden (2003)).

<table>
<thead>
<tr>
<th>Location</th>
<th>Additional Flow Requirement (TAF)</th>
<th>Hydrologic Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>American (Nimbus)</td>
<td>55</td>
<td>Sacramento River</td>
</tr>
<tr>
<td>Stanislaus (Goodwin)</td>
<td>34</td>
<td>San Joaquin River</td>
</tr>
<tr>
<td>ERP #1 Flow Objective</td>
<td>0</td>
<td>Sacramento River</td>
</tr>
<tr>
<td>ERP #2 Flow Objective</td>
<td>65</td>
<td>Sacramento River</td>
</tr>
<tr>
<td>EFP #4 Freeport (Dayflow)</td>
<td>0</td>
<td>Sacramento River</td>
</tr>
<tr>
<td>Trinity (Lewiston)</td>
<td>344</td>
<td>North Coast</td>
</tr>
<tr>
<td>SJR at Vernalis (Dayflow)</td>
<td>96</td>
<td>San Joaquin River</td>
</tr>
<tr>
<td>SJR below Friant</td>
<td>268</td>
<td>San Joaquin River</td>
</tr>
<tr>
<td>Level 4 Refuge Water¹</td>
<td>125</td>
<td>Sacramento and San Joaquin Rivers</td>
</tr>
</tbody>
</table>

TOTAL (TAF) 987

¹ Annual water needed in addition to current deliveries to 19 Sacramento and San Joaquin refuges, evenly split between the Sacramento and San Joaquin River regions.
### Table 14: Model parameters for 2005 State Water Plan narrative scenarios.

<table>
<thead>
<tr>
<th>Narrative Scenario Factors</th>
<th>Model Parameters</th>
<th>Initial Conditions (2000)</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Current Trends</td>
<td>Less Resource Intensive</td>
<td>More Resource Intensive</td>
<td></td>
</tr>
<tr>
<td>Total Population</td>
<td>See Population Distribution</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Population Density</td>
<td>Share of MF housing by HR</td>
<td>2000 Values</td>
<td>2030 DOF Forecast</td>
<td>2030 DOF + 10%</td>
<td>2030 DOF + 5%</td>
</tr>
<tr>
<td></td>
<td>Persons per SF household by HR</td>
<td>2000 Values</td>
<td>2030 DOF Forecast</td>
<td>2030 DOF + 0.2</td>
<td>2030 DOF</td>
</tr>
<tr>
<td></td>
<td>Persons per MF household by HR</td>
<td>2000 Values</td>
<td>2030 DOF Forecast</td>
<td>2030 DOF + 0.2</td>
<td>2030 DOF</td>
</tr>
<tr>
<td>Population Distribution</td>
<td>Inland &amp; Southern Population (mil)</td>
<td>2000 Values</td>
<td>2030 DOF Forecast</td>
<td>2030 DOF</td>
<td>12% DOF</td>
</tr>
<tr>
<td></td>
<td>Coastal &amp; Northern Population (mil)</td>
<td>2000 Values</td>
<td>2030 DOF Forecast</td>
<td>2030 DOF</td>
<td>11% DOF</td>
</tr>
<tr>
<td>Commercial Activity</td>
<td>Employment Fraction by HR</td>
<td>2000 Values</td>
<td>Woods &amp; Poole Forecast</td>
<td>W&amp;P + 2.5%</td>
<td>W&amp;P</td>
</tr>
<tr>
<td></td>
<td>Commercial Fraction by HR</td>
<td>2000 Values</td>
<td>Woods &amp; Poole Forecast</td>
<td>W&amp;P</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Response to Water Price</td>
<td>Captured by NOC and Urban Efficiency</td>
<td>See Naturally Occurring Conservation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Industrial Activity</td>
<td>Employment Fraction by HR</td>
<td>2000 Values</td>
<td>Woods &amp; Poole Forecast</td>
<td>W&amp;P + 2.5%</td>
<td>W&amp;P</td>
</tr>
<tr>
<td></td>
<td>Industrial Fraction by HR</td>
<td>2000 Values</td>
<td>Woods &amp; Poole Forecast</td>
<td>W&amp;P</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use response to Water Price</td>
<td>Captured by NOC</td>
<td>See Naturally Occurring Conservation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crop Unit Water Use</td>
<td>Evapotranspiration (ET) by HR and crop Effective Precipitation (EP) by HR and crop Consumption Fraction (CF)</td>
<td>2000 Estimates</td>
<td>Computed from 2000 estimates modified by factors below</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agricultural Yield</td>
<td>2000 Estimates</td>
<td>2030 DOF Forecast</td>
<td>2030 DOF + 10%</td>
<td>2030 DOF + 5%</td>
</tr>
<tr>
<td></td>
<td>ET Response to Yield (ET-Yield Elasticity)</td>
<td>n/a</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Irrigation Technique on ET</td>
<td>n/a</td>
<td>0.0%</td>
<td>-2.5%</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>CF Response to price (CF-Price Elasticity)</td>
<td>n/a</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>Environment-Water-Pine Based Environmental-Water-Land Based</td>
<td>Computed from Irrigated Land Area and Multi-cropped Fraction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unmet flow requirements as quantified by Environmental Defense</td>
<td>2000 Environmental Demand</td>
<td>2000 Env. Demand + 50%</td>
<td>2000 Env. Demand + 100% ED Unmet Flow</td>
<td>2000 Env. Demand</td>
</tr>
<tr>
<td>Naturally Occurring Conservation (NOC)</td>
<td>Relative Urban Water Prices</td>
<td>2000 Prices</td>
<td>120% of 2000 Prices</td>
<td>120% of 2000 Prices</td>
<td>120% of 2000 Prices</td>
</tr>
<tr>
<td></td>
<td>SF Price Elasticity</td>
<td>n/a</td>
<td>-0.16</td>
<td>-0.35</td>
<td>-0.65</td>
</tr>
<tr>
<td></td>
<td>MP Price Elasticity</td>
<td>n/a</td>
<td>-0.05</td>
<td>-0.05</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>Irrigated Crop Area*</td>
<td>n/a</td>
<td>0.4</td>
<td>0.2</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>SF Income Elasticity</td>
<td>n/a</td>
<td>0.45</td>
<td>0.25</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>MF Income Elasticity</td>
<td>n/a</td>
<td>0.4</td>
<td>0.2</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>SF HH Size Elasticity</td>
<td>n/a</td>
<td>0.5</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>MF HH Size Elasticity</td>
<td>n/a</td>
<td>0.5</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>NOC - Domestic (interior &amp; exterior)</td>
<td>n/a</td>
<td>-10%</td>
<td>-10%</td>
<td>-10%</td>
</tr>
<tr>
<td></td>
<td>Commercial Price Elasticity</td>
<td>n/a</td>
<td>-0.05</td>
<td>-0.1</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>NOC - Commercial</td>
<td>n/a</td>
<td>-10%</td>
<td>-10%</td>
<td>-10%</td>
</tr>
<tr>
<td></td>
<td>Industrial Price Elasticity</td>
<td>n/a</td>
<td>-0.05</td>
<td>-0.1</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>NOC - Industrial</td>
<td>n/a</td>
<td>-10%</td>
<td>-10%</td>
<td>-10%</td>
</tr>
<tr>
<td></td>
<td>NOC - Public</td>
<td>n/a</td>
<td>-10%</td>
<td>-10%</td>
<td>-10%</td>
</tr>
<tr>
<td>Urban Water Use Efficiency</td>
<td>Efficiency - Domestic (interior &amp; exterior)</td>
<td>n/a</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
<tr>
<td></td>
<td>Efficiency - Commercial</td>
<td>n/a</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
<tr>
<td></td>
<td>Efficiency - Industrial</td>
<td>n/a</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
<tr>
<td></td>
<td>Efficiency - Public</td>
<td>n/a</td>
<td>-5%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
<tr>
<td>Ag Water Use Efficiency</td>
<td>Irrigation Technique on ET Technology on CF</td>
<td>See Crop Water Use</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4 Results

The water demand scenario generator computes water demand for each of the State’s ten hydrologic regions. To focus attention on the main trends and challenges facing California, we divide the state into thirds (Figure 4). When necessary to reflect important differences within these large zones, the North zone is disaggregated into the Mountain North\(^{27}\) and Valley North,\(^{28}\) and the Central zone is disaggregated into the Coast Central\(^{29}\) and Valley South.\(^{30}\) The South remains the same.\(^{31}\) The results shown in Appendix 1 are presented using the five regions.

![Figure 4: Three different geographic divisions of the state.](image)

4.1 Urban demand drivers

In all four scenarios, statewide population growth is large as specified by the scenario input parameters (Figure 5). Population growth from 2000 to 2030 ranges from about 10.5 million people in the Low Water Demand Scenario to over 18 million people in the More Resource Intensive scenario (the State’s population in 2000 was 34.1 million). Population growth is largest in the South and smallest in the North. Changes in employment (Figure 5) and housing (Figure 6) are largely proportional to population growth.

\(^{27}\) The Mountain North is the combination of the North Coast and North Lahontan hydrologic regions.
\(^{28}\) The Valley North is the Sacramento River hydrologic region.
\(^{29}\) The Coast Central is the combination of the San Francisco and Central Coast hydrologic regions.
\(^{30}\) The Valley South is the combination of the San Joaquin River and Tulare Lake hydrologic regions.
\(^{31}\) The South is the combination of the South Coast, Colorado River, and South Lahontan hydrologic regions.
The state’s housing stock is comprised of more multifamily housing units in the Less Resource Intensive and Low Water Demand scenarios than the others (Figure 6).

![Figure 5: Projected changes in population and employment from 2000 to 2030 for each scenario. The year 2000 population was 34.1. There were 19.8 million employees in 2000.](image)

![Figure 6: Projected changes in housing from 2000 to 2030 (left) and statewide housing share for each scenario (right). The housing stock in 2000 was 11.6 million units.](image)

In the agricultural sector, the irrigated crop area (ICA) decreases about 5% from 9.5 million acres in 2000 to about 9.1 million acres in 2030 in the Current Trends and Low Water demand scenarios. ICA remains constant in the Less Resource Intensive and More Resource Intensive scenarios as specified (Figure 7). In all scenarios, ICA increases in the North regions and decreases in the Central and South regions.
ICA increases in the North are due to both increases in irrigated land area (consistent with the 1998 Water Plan forecast) and to greater multi-cropping.

![Irrigated crop area change (2000 - 2030)](image1)

**Figure 7:** Projected changes in irrigated crop area and multi-crop area from 2000 to 2030 for each scenario and third of the state. Plus symbols indicate total changes.

### 4.2 Water demand changes

Care must be taken when interpreting the results of the water demand scenario generator. The four scenarios, by design, reflect what water demand might be (1) under specific assumptions of future water price, (2) if no additional water management strategies were implemented, and (3) under average climatic conditions. The water demand estimates presented for these scenarios can be significantly influenced by policy actions, and thus the change in water demand is not necessarily the amount of new supply required to meet future needs.

Statewide urban water demand is projected to increase from 2000 to 2030 in all four scenarios (Figure 8). The symbols characterizing the scenarios (in the plot legend) show that urban demand is greatest for the scenario with large population growth and lower water conservation. Scenarios with lower population growth and more conservation show slower demand increases. Demand increases the most (by about 6 MAF) in the More Resource Intensive scenario and the least (less than 1 MAF) in the Low Water Demand scenario (Figure 9). In the Current Trends scenario, demand increases by about 3 MAF. The urban demand changes are greatest in the South for the Current Trends and More Resource Intensive scenarios, but larger for the Central region in the Less Resource Intensive and Low Water Demand scenarios. The relatively large increases
in naturally occurring conservation in the Less Resource Intensive and Low Water Demand scenarios drive large absolute water savings from existing urban development. As urban use is greater in the South than in the Central or Northern regions, the relative efficiency gains produce the greatest absolute savings in the south. These water savings offsets much of the population growth in the South.

![State-wide Urban Water Demand](image)

**Figure 8:** Average-year urban water demand from 2000 to 2030 for each scenario (see Table 6 for legend of symbols).
Figure 10 shows the agricultural water demand from 2000 to 2030 for each scenario. Water demand is projected to decrease for all four scenarios because each scenario assumes a reduction in irrigated land area and decreased crop water use. Those scenarios with lower irrigated crop area (ICA) and greatest crop water use reductions (see legend in figure) have lower 2030 water demand. Agricultural demand reductions are largest in the Low Water Demand scenario, as it reflects a large reduction in irrigated land area (same as Current Trends) and a large decrease in effective crop water use (same as Less Resource Intensive). Agricultural water demand reduction is least in the More Resource Intensive scenario due primarily to lower efficiency gains than in the Less Resource Intensive scenario. Note that the range of changes in agricultural water demand is about equal to the demand change for the More Resource Intensive scenario, suggesting that policies aimed at influencing the scenarios can have an important effect upon water demand changes.

Figure 11 shows the agricultural demand changes by geographic region and scenario. Agricultural demand changes in the South are similar across the scenarios, whereas demand changes vary significantly in the North and Central regions.
Finally, changes in environmental water demand range from no increase for the More Resource Intensive scenario to about 1.5 MAF for the Low Water Demand scenario (150% of the Environmental Defense partial unmet demand) (Table 15). In 2030 in the Low Water Demand scenario, large environmental allocations and lower urban and agricultural use lead the statewide environmental water use to be over 50% of the total demand. In the More Resource Intensive scenario environmental demand is only 46% of the total water demand.

Table 15: Change in environmental water demand and 2030 percentage of total demand.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Change in environmental water demand</th>
<th>Percent environmental demand in 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Trends (→ allocation)</td>
<td>494</td>
<td>48%</td>
</tr>
<tr>
<td>Less Resource Intensive (↑ allocation)</td>
<td>987</td>
<td>49%</td>
</tr>
<tr>
<td>More Resource Intensive (↓ allocation)</td>
<td>0</td>
<td>46%</td>
</tr>
<tr>
<td>Low Water Demand (↑↑ allocation)</td>
<td>1,481</td>
<td>51%</td>
</tr>
</tbody>
</table>

Figure 12 – Figure 14 show the water demand changes by sector for the Northern, Central, and Southern regions, respectively. In the Northern regions (Figure 12) urban water demand change is large for the Current Trends and More Resource Intensive scenarios and more modest for the other scenarios. Environmental water demand change is significant for the Current Trends, Less Resource Intensive, and Low Water Demand scenarios. In the Central regions (Figure 13), urban water demand increases and agricultural demand decreases in all scenarios. For the Current Trends, Less Resource Intensive, and Low Water Demand
scenarios, the net change in water demand is negative. For the More Resource Intensive scenario it is positive. Finally, in the Southern regions (Figure 14) urban water demand increases for all scenarios (although the increase is slight for the Low Water Demand scenario). The urban demand changes, however, vary considerably across scenarios. Agricultural demand changes are slightly negative across all the scenarios. The net water demand change is positive for the Current Trends and More Resource Intensive scenario and negative for the Less Resource Intensive and Low Water Demand scenarios.

Figure 12: Scenarios of demand changes in Northern regions by sector, 2000-2030.

Figure 13: Scenarios of demand changes in Central regions by sector, 2000-2030.
4.3 Water demand change decomposition

Changes in water demand can be decomposed into the portions of change attributable to each of the factors defining water demand. For example, the change in single family water use from the year 2000 to year 2030 ($\Delta U_{SF}$) can be decomposed into the change due to variation in the number of single family households ($\Delta HH_{SF}$ term) and the change due to variations in per household water use ($\Delta U_{SF}Use_{SF}$ term), and a residual joint change term ($Joint$ change term):

$$\Delta U_{SF} = Use_{SF,2030} - Use_{SF,2000}$$

(29)

where

$$Use_{SF} = (HH_{SF} \cdot Use_{SF})$$

(30)

Combining Equations 29 and 30 yields:

$$\Delta U_{SF} = (HH_{SF,2030} \cdot Use_{SF,2030}) - (HH_{SF,2000} \cdot Use_{SF,2000})$$

(31)

Since

$$HH_{SF,2030} = HH_{SF,2000} + \Delta HH_{SF}$$

and

$$Use_{SF,2030} = Use_{SF,2000} + \Delta Use_{SF}$$

(32)

(33)

Equation 31 can be rewritten as:

$$\Delta U_{SF} = (HH_{SF,2000} + \Delta HH_{SF} \cdot (Use_{SF,2000} + \Delta Use_{SF}) - HH_{SF,2000} \cdot Use_{SF,2000}$$

(34)

Distributing the terms and canceling yields the final decomposition:
\[ \Delta \text{Use}_{\text{SF}} = \left( \text{UseCoef}_{\text{SF},2000} \cdot \Delta \text{HH}_{\text{SF}} \right) + \left( \text{HH}_{\text{SF},2000} \cdot \Delta \text{UseCoef}_{\text{SF}} \right) + \left( \Delta \text{HH}_{\text{SF}} \cdot \Delta \text{UseCoef}_{\text{SF}} \right) \]  

(35)

or

\[ \Delta \text{Use}_{\text{SF}} = \{ \Delta \text{HH} \text{ term} \} + \{ \Delta \text{UseCoef} \text{ term} \} + \{ \text{Joint change term} \} \]  

(36)

Note that as the factor changes approach zero in the limit, the joint change term approaches zero and Equation 34 becomes equivalent to taking the total derivative of single family water use with respect to time by applying the chain rule:

\[ \frac{D}{Dt} \left( \text{Use}_{\text{SF}} \right) = \frac{D}{Dt} \left( \text{HH}_{\text{SF}} \cdot \text{UseCoef}_{\text{SF}} \right) \]  

(37)

\[ \frac{D}{Dt} \left( \text{Use}_{\text{SF}} \right) = \left( \text{UseCoef}_{\text{SF}} \cdot \frac{\partial}{\partial t} \text{HH}_{\text{SF}} \right) + \left( \text{HH}_{\text{SF}} \cdot \frac{\partial}{\partial t} \text{UseCoef}_{\text{SF}} \right) \]  

(38)

Figure 15 shows these three terms and the total water demand change for households (single- and multi-family houses) for each scenario. Asterisk symbols denote the total water use changes and the height of the bars indicate the magnitude and sign of each change terms. This figure shows that for all four scenarios, population changes alone (light grey bars) lead to large water demand increases (over 1.5 MAF for the Low Water Demand scenario to about 3 MAF for the More Resource Intensive scenario). For the Less Resource Intensive and Low Water Demand scenarios, however, decreases in household water use compensates for more than half of the entire increase due to the increase in the number of households. For Current Trends and More Resource Intensive, per household water use changes (the dark layers Figure 15) are either only slightly negative or are positive despite the fact that both scenarios were specified to reflect increasing water use efficiency (NOC plus Efficiency).
To examine the forces behind the Per Household Demand changes, Figure 16 shows how the Per Household Water Demand coefficient changes in response to changes in individual driving factors. For example, NOC and Efficiency effects alone would decrease household water use by 15%, 20%, 15%, and 20% respectively (the first vertical bar in the figure). The effect of price is not very large in all scenarios, indicating that the specified 20% price change over 30 years will have at most only a small effect on water demand. Changes in income (the middle vertical bar in the figure) are substantial (ranging between about 7% to over 20%). Demographic changes are those attributable to the location of new housing. Scenarios (such as the More Resource Intensive scenario), in which population growth is greater in high water use regions, have a greater demographic household water use effect. Notice that this effect exceeds 5% for the More Resource Intensive scenario.
Changes in Per Household Water Demand (2000 - 2030)

Figure 16: Changes in statewide per household water demand from 2000-2030 due to NOC/Efficiency, Water Price, Income, and Demographics. See text for explanation.

Water demand for irrigation changes over time in response to variations in the total irrigated crop area and the amount of water used for each crop. Using a methodology similar to that described for household water use, we decompose irrigation water demand changes into the following four components: low value crop water use, high value crop water use, low value ICA, and high value ICA (Figure 17). For all four scenarios, changes in crop water use reduces water demand. These changes are proportionally larger for low value crops than high value crops. In all scenarios, ICA for low value crops decreases and thus reduces water demand. In the Less Resource Intensive and More Resource Intensive scenarios, ICA increases for high value crops and thus increases demand. The change in crop mix is caused by increases in high value crops that can be multi-cropped.
4.4 Effects of price and policy-induced efficiency on urban demand

Each scenario of water demand assumes a specific water price and no additional water use efficiency policies. Figure 18 shows how statewide urban water demand changes as a function of water price changes for each scenario. The dots indicate the water quantity demand as specified in the previous sections. For all scenarios, as price increases, demand changes from 2000 to 2030 are reduced. The changes by price are larger for the Low Water Demand and Less Resource Intensive scenarios due to greater water use price elasticity factors specified.
Figure 18: Statewide urban water demand changes for each scenario as a function of water price changes (as a percentage of 2000 water price). The dots indicate the values corresponding to a 27.3% price increase.

Figure 19 shows how urban water demand would change in response to additional policy-induced efficiency (at 5% improvement increments) for the entire state. Such efficiency improvement could be achieved, in part, through the implementation of the urban water use efficiency resource management strategies described in Volume 2 of the 2005 California Water Plan. The larger efficiency improvements shown in Figure 19 may require efficiency measures that are more aggressive than those considered in the Water Plan. Also, any particular efficiency program is likely to have different effects across the scenarios. This analysis does not evaluate the feasibility of such improvements, but instead illustrates the effect that new urban water use efficiency management policies could have upon the presented water demand scenarios.

Additional efficiency improvements of 15% would result in a statewide water demand increase of only about 1 MAF under the Current Trends scenario, water demand decreases in the Less Resource Intensive and Low Water Demand scenarios, and water demand increases of less than 3.5 MAF in the More Resource Intensive scenario.

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32 These results are generated by decreasing in 5% increments (from -5%) the urban water use efficiency factors for each scenario (reported in Table 8 and Table 9).
Conclusions and recommendations for further research

5.1 Water management findings

Four scenarios of year 2030 water demand in California are quantified and reveal several important insights about future California water resource management challenges. Findings related to urban water demand include the following:

1) If no new water management strategies are implemented, water demand for urban consumption in California will increase from 2000 to 2030 in response to population and economic growth.

2) Significant uncertainties about demographic trends, water use behavior, and penetration of water efficiency technologies over the scenario period suggest a wide range of plausible urban demand increases, spanning the range of 1 MAF to 6 MAF. These increases can be tempered significantly by increasing water prices or increasing water use efficiency through additional management policies.

3) Scenarios with high population growth and low naturally occurring conservation will lead to the greatest water demand increases.

4) Even if conservation were to reduce statewide water use at the same rate as population growth, urban water demand would increase as new housing and economic development will occur largely in high water using regions.

5) Variation in demand changes across regions is substantial. The Southern region will experience the greatest demand increases under high population and low conservation scenarios.

Findings related to agricultural water demand include:
6) Demand for water in the agriculture sector decreases under all scenarios considered, although it decreases the most under the Current Trends scenario and not the Less Resource Intensive scenario.\footnote{Irrigated land area decreases less in the Less Resource Intensive scenario than in the Current Trends scenario, leading to greater agricultural water use in the Less Resource Intensive scenario.}

7) Scenarios in which urban growth induces conversion of farmland may also lead to large decreases in agricultural water demand.

8) Trends towards multi-cropping and lower crop water use through more efficient practices and crop varieties could enable the agriculture sector to maintain existing production (proxied in this model by irrigated crop area) while consuming substantially less water.

Finally, under the four scenarios considered, water allocations to the environment would increase environmental demand by up to 1.5 MAF.

Estimates of future statewide average-year water demands, however small or large, do not adequately characterize the challenges facing California water managers. Increases in water demand must be addressed at regional and local scales because available supplies in one part of the state cannot necessarily be used to meet rising demands in another part. Furthermore, the timing of demand and supply and interannual variability of supply are masked by average-year balances.

Greater urban water demand under all but the low water demand scenario would present significant challenges to water planners. If future factors influencing water demand resemble the Current Trends scenario, California would need to offset an additional 3.5 MAF of urban and environmental water demand per year with a combination of management strategies to reduce demand, improve system efficiency, and redistribute and augment supplies. As seen by the regional results above, most of the agricultural demand reductions occur in the Central Valley, whereas much of the additional urban demand would be in the Southern part of the state. The ability to transfer water from the Central Valley to Southern California could be constrained by existing conveyance facilities, area-of-origin issues, environmental impacts, and other third-party effects.

If future water demand changes are more like the More Resource Intensive scenario, water management challenges would be even greater. Demand would increase in all areas of California, and agricultural demand would not decrease as much as it does in the other three scenarios. Consequently, the reduction in agricultural demand would only offset a portion of the increase in urban demand. The demand changes in the Less Resource Intensive and Low Water Demand scenarios would be more manageable than
the other two scenarios. If, however, future water supplies are lower due to climate change, for example, then even these scenarios could present considerable challenges for California water management.

Other challenges not captured by this analysis exist as well. As local demands increase, future droughts could result in more severe local water shortages than in recent experience. Moreover, the challenges of flood management, protecting water quality, and managing water systems to help restore the environment will all require California’s water managers to develop strong water plans that go well beyond just meeting water demand increases in average years.

5.2 Methodological observations

The three Water Plan scenarios do not appear to bracket the plausible range of water demand, because low resource intensive urban development leads to less urban sprawl in this model, it also leads to lower reductions in agricultural land and thus less reduction in agricultural water demand. This issue raised concern during the January, 2005 Advisory Committee meeting, though this result is not due to an erroneous quantification of the scenarios. Instead, it is due to basing the two bracketing scenarios on resource sustainability rather than another factor more correlated to water use.

Such unanticipated results help provide better clarity of the implications of the scenarios. It also illustrates an important limitation to conventional scenario analysis. First, for collaborative decision making processes, a few scenarios are unlikely to reflect all the important futures that stakeholders will have concern about. For example, the analysis presented here motivated a study by the Pacific Institute (Gleick et al. 2005) to develop a high efficiency water demand scenario based on a modified version of the water demand model described above. The purpose of this scenario is to quantify a scenario of water demand that is congruent with Pacific Institute’s 2003 assessment of plausible cost-effective urban water efficiency (Gleick et al. 2003).

There is also no guarantee that the scenarios developed by DWR and quantified in this article are those most relevant to the choice of policies. In a recent doctoral dissertation by Groves (2005), a new analytic method for decision making under deep uncertainty, called Robust Decision Making (RDM), is demonstrated using a modified version of the water demand generator used in this article. RDM uses scenario generators with exploratory modeling software tools to evaluate numerous scenarios, identify the vulnerabilities of leading policies or management strategies, and identify alternative policies that are robust across the most relevant uncertainties about the future.

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54 Groves (2005) is available from the RAND website (www.rand.org/Abstracts/).
5.3 Recommendations for future research

Several areas of promising research were revealed in the course of this study. Some of these could involve further development of the present scenario generator, while others might entail development of independent models that interact with the generator in modular fashion. Potentially fruitful avenues of development include:

- Making explicit the ability to take as input the output from various probabilistic forecasting models such as IWR-MAIN and CALAG. For example, IWR-MAIN might be used to estimate the “other effects” category of urban water use, which accounts for those changes caused by the adoption of more efficient water use technologies, conservation programs, and behavioral changes not captured by efficiency factors. Similarly, CALAG might be used to estimate the current trends scenario of irrigated crop area, with alternate scenarios keying off of the current trends estimate.

- Explicitly treating and accounting for consumptive and non-consumptive water uses to better describe the effects of change in water use on regional water supplies.

- Expanding the scope of the generator or separately modeling water supplies to account for the effects of water supply variation and distribution system limitations.

- Expanding the scope of the generator or separately modeling the effects of various water management options on water demand and supply.
Appendix 1 – Detailed results

This appendix is included for the review of the Water Plan staff, Water Plan Advisory Committee, and other interested members of the public. See Figure 4 for a description of the five geographic regions used below.

Table 16: Urban demand drivers for 2000 and 2030 for each scenario.

<table>
<thead>
<tr>
<th>Demand Drivers</th>
<th>Year 2000</th>
<th>Year 2030 by scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Current Trends</td>
</tr>
<tr>
<td>Population</td>
<td>34.1</td>
<td>48.1</td>
</tr>
<tr>
<td>Mountain North</td>
<td>0.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Valley North</td>
<td>2.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Valley South</td>
<td>3.6</td>
<td>6.5</td>
</tr>
<tr>
<td>Coast Central</td>
<td>7.6</td>
<td>9.7</td>
</tr>
<tr>
<td>South</td>
<td>19.6</td>
<td>26.3</td>
</tr>
<tr>
<td>Houses (SF%)*</td>
<td>11.6 (64)</td>
<td>16.7 (66)</td>
</tr>
<tr>
<td>Mountain North</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Valley North</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Valley South</td>
<td>1.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Coast Central</td>
<td>2.7</td>
<td>3.6</td>
</tr>
<tr>
<td>South</td>
<td>6.5</td>
<td>8.8</td>
</tr>
<tr>
<td>Employees (C%)**</td>
<td>19.8 (83)</td>
<td>28.8 (86)</td>
</tr>
<tr>
<td>Mountain North</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Valley North</td>
<td>1.4</td>
<td>2.7</td>
</tr>
<tr>
<td>Valley South</td>
<td>1.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Coast Central</td>
<td>5.1</td>
<td>7.2</td>
</tr>
<tr>
<td>South</td>
<td>11.1</td>
<td>15.5</td>
</tr>
</tbody>
</table>

* Number in parentheses indicates percentage of single-family housing.

** Number in parentheses indicates percentage of commercial employees.
### Table 17: Urban water use coefficients for 2000 and 2030 for each scenario.

<table>
<thead>
<tr>
<th>Water Use Coefficients</th>
<th>Year 2000</th>
<th>Year 2030 by scenario</th>
<th>Year 2030 by scenario</th>
<th>Year 2030 by scenario</th>
<th>Year 2030 by scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Current Trends</td>
<td>Less Resource Intensive</td>
<td>More Resource Intensive</td>
<td>Low Water Demand</td>
</tr>
<tr>
<td>Per Household Demand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(AF/unit-year)</td>
<td>(AF/unit-year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Household Demand</td>
<td>0.48</td>
<td>0.46</td>
<td>0.39</td>
<td>0.55</td>
<td>0.39</td>
</tr>
<tr>
<td>(SF/MF)*</td>
<td>(0.54/0.36)</td>
<td>(0.52/0.37)</td>
<td>(0.44/0.34)</td>
<td>(0.6/0.41)</td>
<td>(0.52/0.37)</td>
</tr>
<tr>
<td>Mountain North</td>
<td>0.37</td>
<td>0.33</td>
<td>0.29</td>
<td>0.38</td>
<td>0.29</td>
</tr>
<tr>
<td>Valley North</td>
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<td>0.51</td>
<td>0.42</td>
<td>0.61</td>
<td>0.42</td>
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<td>Valley South</td>
<td>0.80</td>
<td>0.73</td>
<td>0.68</td>
<td>0.80</td>
<td>0.68</td>
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<td>Coast Central</td>
<td>0.32</td>
<td>0.29</td>
<td>0.25</td>
<td>0.33</td>
<td>0.25</td>
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<td>South</td>
<td>0.49</td>
<td>0.47</td>
<td>0.38</td>
<td>0.56</td>
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<tr>
<td>Per Employee Demand</td>
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<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(C/I)**</td>
<td>(0.1/0.17)</td>
<td>(0.08/0.15)</td>
<td>(0.08/0.14)</td>
<td>(0.09/0.16)</td>
<td>(0.08/0.15)</td>
</tr>
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<td>0.12</td>
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<td>0.10</td>
<td>0.09</td>
<td>0.11</td>
<td>0.09</td>
</tr>
<tr>
<td>Coast Central</td>
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<td>0.06</td>
<td>0.05</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>South</td>
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<td>0.10</td>
<td>0.09</td>
</tr>
<tr>
<td>Per Person Public Demand</td>
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<td>0.02</td>
<td>0.02</td>
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<tr>
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<td>South</td>
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<td>0.03</td>
<td>0.03</td>
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</tr>
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</table>

* Numbers in parentheses are SF and MF household use coefficients.

** Numbers in parentheses are commercial and industrial employees water use coefficients.
Table 18: Agricultural land use and effective crop water use for 2000 and 2030 for each scenario.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Year 2000</th>
<th>Year 2030 by scenario</th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Current Trends</td>
<td>Less Resource Intensive</td>
<td>More Resource Intensive</td>
<td>Low Water Demand</td>
<td></td>
</tr>
<tr>
<td>Irrigated Crop Area*</td>
<td>9,510</td>
<td>9,050</td>
<td>9,520</td>
<td>9,500</td>
<td>9,050</td>
<td></td>
</tr>
<tr>
<td>Mountain North</td>
<td>450</td>
<td>500</td>
<td>480</td>
<td>500</td>
<td>490</td>
<td></td>
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<tr>
<td>Valley North</td>
<td>2,040</td>
<td>2,070</td>
<td>2,200</td>
<td>2,190</td>
<td>2,080</td>
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<tr>
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<td>4,920</td>
<td>5,210</td>
<td>5,210</td>
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<tr>
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<td>620</td>
<td>650</td>
<td>620</td>
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<tr>
<td>South</td>
<td>1,080</td>
<td>930</td>
<td>990</td>
<td>980</td>
<td>920</td>
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<tr>
<td>Irrigated Land Area*</td>
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<td>480</td>
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<td>470</td>
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<tr>
<td>South</td>
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<td>780</td>
<td>830</td>
<td>780</td>
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<tr>
<td>Multi-cropped Area*</td>
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<td>970</td>
<td>990</td>
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<td>530</td>
<td>800</td>
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<tr>
<td>South</td>
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<td>160</td>
<td>160</td>
<td>210</td>
<td>120</td>
<td></td>
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<tr>
<td>Effective Crop Water Use**</td>
<td>3.42</td>
<td>3.41</td>
<td>3.30</td>
<td>3.58</td>
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<td>Mountain North</td>
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<td>2.70</td>
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<tr>
<td>South</td>
<td>5.23</td>
<td>5.13</td>
<td>4.99</td>
<td>5.22</td>
<td>5.26</td>
<td></td>
</tr>
</tbody>
</table>

* Areas in thousands of acres.

** Effective crop water use is the ratio of irrigation water use divided by the irrigated land area (acre-feet per acre).
Table 19: Statewide urban water demands by sector for 2000 and 2030 for each scenario.

<table>
<thead>
<tr>
<th>Water Demand (in MAF)</th>
<th>Year 2000</th>
<th>Year 2030 by scenario</th>
<th>Current Trends</th>
<th>Less Resource Intensive</th>
<th>More Resource Intensive</th>
<th>Low Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Urban</strong>*</td>
<td>8.9</td>
<td>11.8</td>
<td>10.2</td>
<td>14.7</td>
<td>9.4</td>
<td></td>
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<tr>
<td>Mountain North</td>
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<td>0.2</td>
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<td>0.3</td>
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* Total urban demand includes losses and groundwater recharge (0.12 MAF).
### Table 20: Statewide agricultural and environmental water demands by sector for 2000 and 2030.

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<th>Year 2000</th>
<th>Year 2030 by scenario</th>
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### Table 21: Water demand changes from 2000 to 2030 by scenario and hydrologic region.

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<td>San Joaquin River</td>
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<tr>
<td>Tulare Lake</td>
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<tr>
<td>North Lahontan</td>
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<tr>
<td>South Lahontan</td>
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<td>Colorado River</td>
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### Table 22: Statewide water demand changes from 2000 to 2030 by sector.

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<tr>
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Table 23a,b: Irrigated area by region for 2000 and three 2030 scenarios (Thousand Acres).

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Change from 2000

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<th>2030 - Low Resource Intensive</th>
<th>2030 - More Resource Intensive</th>
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<td>MA</td>
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</tr>
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<td>-7%</td>
<td>-100%</td>
</tr>
<tr>
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<td>NL</td>
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<tr>
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<td>-5%</td>
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Table 24a,b: Water use by region for 2000 and three 2030 scenarios (TAF).

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<td>Ag WU</td>
<td>Env WU</td>
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<td>110</td>
<td>28</td>
<td>1,207</td>
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<tr>
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<td>1,016</td>
<td>125</td>
<td>1,437</td>
</tr>
<tr>
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<td>908</td>
<td>76</td>
<td>5,233</td>
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<td>23,060</td>
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<td>4,637</td>
<td>12,260</td>
</tr>
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<td>1,405</td>
<td>12,860</td>
</tr>
<tr>
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<td>344</td>
<td>856</td>
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<td>34,220</td>
<td>39,410</td>
<td>82,500</td>
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Change from 2000
- Urb WU: 33% -10% 1% 0%
- Ag WU: 15% -8% 3% -1%
- Env WU: 66% -5% 0% 5%
Table 25a, b: Change in water use from 2000 by region for three 2030 scenarios (TAF)

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<td>20,150</td>
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<td>178</td>
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<td>594</td>
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Change from 2000

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<td>2%</td>
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<td>-37%</td>
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<td>1%</td>
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<td>-7%</td>
<td>35%</td>
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<td>0%</td>
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<td>82%</td>
<td>-8%</td>
<td>0%</td>
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<td>NL</td>
<td>16%</td>
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<td>9%</td>
<td>7%</td>
<td>0%</td>
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<td>33%</td>
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<td>9%</td>
<td>28%</td>
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<td>0%</td>
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<td>114%</td>
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<td>27%</td>
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<td>-16%</td>
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<td>-5%</td>
<td>39%</td>
<td>-13%</td>
<td>0%</td>
<td>-6%</td>
<td>104%</td>
<td>-13%</td>
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<td>0%</td>
<td>15%</td>
<td>-8%</td>
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<td>5%</td>
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</table>
California Water Plan Update 2005

Table 26: Irrigated area (thousand acres) for North Coast, San Francisco Bay, and Central Coast for 2000 and 2030
by scenario.
Crops

NORTH COAST

SAN FRANCISCO BAY

CENTRAL COAST

2000

CT

LRI

MRI

2000

CT

LRI

MRI

2000

CT

LRI

Grain

54.0

54.0

54.0

54.0

1.2

0.0

0.1

0.3

16.9

8.6

8.6

MRI

4.2

Rice

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

Cotton

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

SgrBeet

4.7

4.7

4.7

4.7

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

Corn

0.7

0.7

0.7

0.7

1.1

0.0

0.0

0.3

3.1

1.6

1.6

0.8

DryBean

0.1

0.1

0.1

0.1

0.5

0.0

0.0

0.1

4.7

2.4

2.4

1.2

Safflwr

0.0

0.0

0.0

0.0

0.8

0.0

0.0

0.2

0.7

0.4

0.4

0.2

Oth Fld

1.4

1.4

1.4

1.4

0.1

0.0

0.0

0.0

1.4

0.7

0.7

0.3

Alfalfa

57.2

57.2

57.2

57.2

0.3

0.7

0.7

0.3

8.6

0.0

0.0

2.2

Pasture

131.0

131.0

131.0

131.0

5.0

11.1

11.7

4.8

9.4

0.0

0.0

2.3

Pr Tom

0.0

0.0

0.0

0.0

0.2

0.0

0.0

0.1

2.6

2.5

2.6

2.5

Fr Tom

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

2.8

2.7

2.9

2.7

Cucurb

0.2

0.2

0.2

0.2

0.7

0.0

0.0

0.5

6.5

6.3

6.6

6.3

On Gar

3.7

4.1

3.9

4.1

0.1

0.0

0.0

0.1

5.8

5.7

5.9

5.7

Potato

11.0

12.2

11.6

12.2

0.0

0.0

0.0

0.0

0.2

0.2

0.2

0.2

408.4

Oth Trk

7.0

7.8

7.4

7.8

6.4

0.0

0.4

4.2

419.2

408.4

426.4

Al Pist

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.8

0.7

0.7

0.7

Oth Dec

4.2

4.7

4.4

4.7

2.7

2.6

2.7

2.7

15.8

15.0

15.7

15.3

Subtrop

0.1

0.1

0.1

0.1

0.2

0.2

0.2

0.2

15.4

14.7

15.4

15.0

Vine

51.3

56.9

54.1

56.9

51.7

50.5

51.7

51.7

91.3

87.1

91.1

89.0

Totals

326.6

335.0

330.8

335.0

71.0

65.0

67.6

65.4

605.0

557.0

581.1

557.0

Table 27: Irrigated area (thousand acres) for South Coast, Sacramento River, and San Joaquin River for 2000 and
2030 by scenario.
Crops

SOUTH COAST

SACRAMENTO RIVER

SAN JOAQUIN RIVER

2000

CT

LRI

MRI

2000

CT

LRI

MRI

2000

CT

LRI

MRI

Grain

13.6

4.1

4.2

3.4

150.5

150.5

150.5

157.6

185.5

164.7

183.4

187.5

Rice

0.0

0.0

0.0

0.0

567.2

567.2

567.2

551.8

19.1

17.0

18.9

18.3

Cotton

0.0

0.0

0.0

0.0

16.9

16.9

16.9

16.4

144.5

128.3

142.9

138.5

SgrBeet

0.0

0.0

0.0

0.0

8.9

8.9

8.9

8.7

18.5

16.4

18.3

17.7

Corn

2.4

0.7

0.7

0.6

116.0

116.0

116.0

121.4

256.7

228.0

253.8

259.4

DryBean

1.3

0.4

0.4

0.3

35.8

35.8

35.8

37.5

46.8

41.6

46.3

47.3

Safflwr

0.0

0.0

0.0

0.0

71.3

71.3

71.3

74.6

12.7

11.3

12.6

12.8

Oth Fld

3.6

1.1

1.1

0.9

38.6

38.6

38.6

40.4

32.0

28.4

31.6

32.3

Alfalfa

7.2

11.7

11.8

1.8

130.9

130.9

130.9

127.4

232.8

206.7

230.2

223.1

Pasture

17.0

27.5

27.7

4.2

306.6

306.6

306.6

298.3

173.1

153.7

171.1

165.9

Pr Tom

0.4

0.2

0.2

0.3

101.8

107.2

128.8

132.9

88.7

88.7

88.7

90.7

Fr Tom

5.3

2.1

2.3

3.9

3.4

3.6

4.3

4.4

27.1

27.1

27.1

27.7

Cucurb

3.7

1.4

1.6

2.7

25.0

26.3

31.6

32.6

38.3

38.3

38.3

39.2

On Gar

1.6

0.6

0.7

1.2

2.4

2.5

3.0

3.1

5.6

5.6

5.6

5.7

Potato

4.7

1.9

2.1

3.5

0.6

0.6

0.8

0.8

3.4

3.4

3.4

3.5

Oth Trk

71.7

28.4

31.5

53.3

13.9

14.6

17.6

18.2

69.2

69.2

69.2

70.8

Al Pist

0.0

0.0

0.0

0.0

131.8

138.8

166.7

164.4

292.5

292.5

292.5

292.5

159.1

Oth Dec

2.9

1.9

2.0

2.1

247.7

260.9

313.4

308.9

159.1

159.1

159.1

Subtrop

139.2

91.7

98.4

103.4

31.2

32.9

39.5

38.9

7.6

7.6

7.6

7.6

5.6

3.7

4.0

4.2

37.4

39.4

47.3

46.6

237.2

237.2

237.2

237.2

280.2

177.5

188.8

186.0

2037.9

2069.6

2195.7

2185.0

2050.4

1924.8

2037.7

2036.9

Vine

Totals

60

Data and Analytical Tools

4 379


Table 28: Irrigated area (thousand acres) for Tulare Lake, North Lahontan, and South Lahontan for 2000 and 2030 by scenario.

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<tr>
<th>Crops</th>
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<th></th>
<th>SOUTH LAHONTAN</th>
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<td>MRI</td>
<td>2000 CT</td>
<td>LRI</td>
<td>MRI</td>
<td>2000 CT</td>
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<td>MRI</td>
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<tr>
<td>Grain</td>
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<td>349.9</td>
<td>442.1</td>
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<td>7.2</td>
<td>6.4</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.7</td>
<td>0.6</td>
<td>0.7</td>
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<td>0.0</td>
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<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
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<td>369.7</td>
<td>325.1</td>
<td>360.5</td>
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<td>55.9</td>
<td>49.1</td>
<td>55.9</td>
<td>30.5</td>
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<td>27.7</td>
<td>30.7</td>
<td>23.8</td>
<td>75.5</td>
<td>99.5</td>
<td>87.5</td>
<td>99.5</td>
<td>18.9</td>
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<td>107.9</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>9.9</td>
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<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>On Gar</td>
<td>41.2</td>
<td>41.2</td>
<td>41.2</td>
<td>52.0</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
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<td>1.1</td>
<td>0.9</td>
<td>1.1</td>
<td>5.4</td>
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<tr>
<td>Al Pist</td>
<td>256.9</td>
<td>256.9</td>
<td>256.9</td>
<td>256.9</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.4</td>
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<td>Oth Dec</td>
<td>205.1</td>
<td>205.1</td>
<td>205.1</td>
<td>205.1</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>Subtrop</td>
<td>209.4</td>
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<td>209.4</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Vine</td>
<td>408.3</td>
<td>408.3</td>
<td>408.3</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
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<td>165.0</td>
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Table 29: Irrigated area (thousand acres) for Colorado River and Statewide for 2000 and 2030 by scenario.

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<th>Crops</th>
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<th>STATEWIDE</th>
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<tbody>
<tr>
<td></td>
<td>2000 CT</td>
<td>LRI</td>
<td>MRI</td>
<td>2000 CT</td>
<td>LRI</td>
<td>MRI</td>
</tr>
<tr>
<td>Grain</td>
<td>72.7</td>
<td>91.9</td>
<td>92.6</td>
<td>105.2</td>
<td>861.6</td>
<td>796.7</td>
</tr>
<tr>
<td>Rice</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>586.8</td>
<td>584.8</td>
</tr>
<tr>
<td>Cotton</td>
<td>26.5</td>
<td>18.3</td>
<td>20.2</td>
<td>16.1</td>
<td>913.2</td>
<td>801.2</td>
</tr>
<tr>
<td>SgrBeet</td>
<td>34.0</td>
<td>23.5</td>
<td>26.0</td>
<td>20.7</td>
<td>94.3</td>
<td>78.3</td>
</tr>
<tr>
<td>Corn</td>
<td>13.2</td>
<td>16.7</td>
<td>16.8</td>
<td>19.1</td>
<td>625.3</td>
<td>567.6</td>
</tr>
<tr>
<td>DryBean</td>
<td>0.8</td>
<td>1.0</td>
<td>1.0</td>
<td>1.1</td>
<td>122.9</td>
<td>110.2</td>
</tr>
<tr>
<td>Safflwr</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>102.0</td>
<td>97.4</td>
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<td>Oth Fld</td>
<td>74.6</td>
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<td>95.1</td>
<td>108.0</td>
<td>191.7</td>
<td>198.6</td>
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<tr>
<td>Alfalfa</td>
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<td>188.1</td>
<td>149.9</td>
<td>1126.2</td>
<td>984.6</td>
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<tr>
<td>Pasture</td>
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<td>50.4</td>
<td>40.2</td>
<td>834.0</td>
<td>818.9</td>
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<td>Pr Tom</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
<td>0.6</td>
<td>302.0</td>
<td>307.0</td>
</tr>
<tr>
<td>Fr Tom</td>
<td>0.8</td>
<td>1.1</td>
<td>1.1</td>
<td>1.3</td>
<td>49.3</td>
<td>46.5</td>
</tr>
<tr>
<td>Cucurb</td>
<td>29.2</td>
<td>38.7</td>
<td>39.8</td>
<td>46.6</td>
<td>133.7</td>
<td>141.2</td>
</tr>
<tr>
<td>On Gar</td>
<td>17.4</td>
<td>23.0</td>
<td>23.7</td>
<td>27.8</td>
<td>80.8</td>
<td>83.3</td>
</tr>
<tr>
<td>Potato</td>
<td>3.5</td>
<td>4.6</td>
<td>4.8</td>
<td>5.6</td>
<td>44.4</td>
<td>43.6</td>
</tr>
<tr>
<td>Oth Trk</td>
<td>98.9</td>
<td>130.9</td>
<td>134.6</td>
<td>157.9</td>
<td>788.7</td>
<td>756.6</td>
</tr>
<tr>
<td>Al Pist</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>682.4</td>
<td>689.3</td>
</tr>
<tr>
<td>Oth Dec</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>639.9</td>
<td>651.8</td>
</tr>
<tr>
<td>Subtrop</td>
<td>30.8</td>
<td>30.8</td>
<td>32.9</td>
<td>34.0</td>
<td>433.9</td>
<td>387.4</td>
</tr>
<tr>
<td>Vine</td>
<td>16.3</td>
<td>16.3</td>
<td>17.4</td>
<td>18.0</td>
<td>899.2</td>
<td>899.4</td>
</tr>
<tr>
<td>Totals</td>
<td>731.9</td>
<td>708.0</td>
<td>745.2</td>
<td>752.3</td>
<td>9512.3</td>
<td>9044.5</td>
</tr>
</tbody>
</table>
Appendix 2 – Documentation of the assumptions and criteria used to develop regional irrigated agricultural acreage for the 2030 Current Trends scenario

Developing statewide estimates of irrigated land area, irrigated crop area, and multicrop area:

The Current Trends scenario acreage level can be estimated by analysis of three physical factors, which are:

1. The amount of irrigated land taken out of crop production – this includes land that is taken out of production permanently and land that is idled. Permanent changes are due to urbanization, salinity problems, and conversions to other uses such as habitat. Idled land are defined as land once cultivated but not cropped for four or more consecutive years occurs due to various economic reasons, such as being temporarily unprofitable, water transfers, government set-aside programs, anticipation of urbanization, etc.

2. The amount of land brought into production or back into production – this would be land that hadn’t been irrigated before (either non-irrigated crop land or undeveloped land) or land that had previously been irrigated and cropped but had been idled due to various economic reasons.

3. The amount of multi-cropping – this would be the amount of cropped area that has more than one crop grown on it per year (for example, wheat followed by corn, or lettuce followed by celery followed by lettuce).

The current trends, or at least recent history, show that some of California’s irrigated agricultural land is being taken out of production (due mainly to urbanization), some new lands are being cropped and irrigated (mainly vines and trees in the coastal areas and at the edge of the Central Valley floor), and that the amount of multi-cropping is increasing.

Developing the net acreage change – Land taken out of production and land brought into production:

For this analysis, available irrigated land acreage data from the Department of Conservation’s Farmland Mapping and Monitoring Program (FMMP) was used for analysis and for determining of percentage change of statewide irrigated farmland from 2000 to 2030. This percent change was then to be applied to the Year 2000 irrigated land area DWR previously developed for the CWPU.

Information developed by FMMP was gathered for the years 1990 – 2000. From their reports, a table of total acreage of irrigated land was created. This included their categories of prime land, farmland of statewide importance, unique farmland, and interim irrigated land. In addition, estimations were made for portions of some counties where data was not collected (Merced 1990, Stanislaus 1990 – 1998, and Modoc and Siskiyou 1990 – 1994) and for all of Lake 1990 – 1994. Estimations were made using the changes in acreage by year for the areas with acreage and applying those changes (in percentage) to the areas where data was not collected in that county. Although the data gathered from FMMP does cover all of California (there are some minor agricultural counties missing, and portions of counties with minimal agriculture are missing), the data used probably represent well over 95 percent of the irrigated agricultural land in the state.
A regression analysis using total irrigated land area as the dependent variable and time as the independent variable was performed. A scatter graph (Figure 20) was created using the time (1990 - 2000) as the x coordinate and the acreage as the y coordinate. A trend line (regression) was developed with an r-squared of 0.99. Using this regression equation, the 2030 acreage would be reduced from the DWR’s 2000 acreage (8,975,000 acres) by 10.1 percent (906,900 acres) to 8,068,100 acres.

\[
y = -30.022x + 69073
\]

\[R^2 = 0.9905\]

Figure 20: Historical trend of statewide irrigated land area.

Obviously, agricultural acreage reduction is not really dependent on time. There are many factors that can and will affect the rate of agricultural land reduction, including the ones below:

- Housing density of new homes
- Amount of infilling within existing urban areas
- Amount of agricultural conservation easements developed
- Amount of development of new land (previously not cropped of irrigated)
- Amount of retirement of land affected by salinity
- Agricultural to urban water transfers (long-term) that would affect the irrigation of land
- Changing conditions in the agricultural market place

Deciding what the “Current Trend” is for each factor, and determining how much it would affect the rate of change of irrigated agricultural land was far too difficult (virtually impossible) for this effort.

We made an assumption that an irrigated agricultural land reduction of 906,900 acres by the year 2030 is plausible.
Developing the amount of multi-cropping acreage:

For this analysis, DWR multi-cropped acreage was used for the time period of 1988 – 2000. A regression analysis was performed using, as the dependent variable, multi-cropping (as a percentage of land acres) and time as the independent variable. A scatter graph (Graph 2) was created for 1988 - 2000. A trend line (regression) was developed with an r-squared of 0.85. Using this regression equation, the 2030 multicropping percentage of land area would be increased from DWR’s 2000 percentage (6.0%) to 11.94%. This equates to a change in multicropped acreage from 537,240 acres in 2000 to 963,330 in 2030, an increase of 426,090 acres.

![Comparison of Percent Multi-Cropping of Land Area with Time (1988 - 2000)](#)

Figure 21: Historical trend of the percentage of irrigated land area that is multicropped.

Recent history suggests that increase in multi-cropping has been a result of increased vegetables on existing land in the Central and Southern Coast and in the San Joaquin Valley, and increased field crops (grown for animal feed) in the Colorado River Region and the San Joaquin Valley. It is probable that, as demand for vegetables increase (because of increased population, increased exports, changes in consumers’ demands, and higher real incomes), the vegetable acreage could increase mainly in the Colorado River Region and in the San Joaquin Valley. With dairy herd increases, there could be increases in field crops for multi-cropping in the Central Valley, and maybe the Colorado River Region.

We made an assumption that a multicropping acreage increase of 426,090 acres by the year 2030 is plausible.

Developing irrigated crop acreage:

As mentioned in the beginning, the irrigated crop acreage is the sum of the irrigated land area and the multicropping acreage. The table below details the information for the year 2000 and 2030, for land area, multi-cropped acreage, and the cropped acreage.
### Developing regional estimates of irrigated land area, irrigated crop area, and multicrop area:

1. Based on the previous Bulletin (160-98), the acreage changes between 1995 and 2020 was negligible for four regions, North Coast, San Francisco Bay, North Lahontan, and South Lahontan. The population pressure on agricultural land in those regions is small.

   We made an assumption that the 2020 acreage (ILA, MC, and ICA) could be plausible for the 2030 level for these four regions.

<table>
<thead>
<tr>
<th>Region</th>
<th>Year 2000 (acres)</th>
<th>Year 2030 (acres)</th>
<th>Change (acres)</th>
<th>Change (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated Land Area</td>
<td>8,975,100</td>
<td>8,068,100</td>
<td>-907,300</td>
<td>-10.1</td>
</tr>
<tr>
<td>Multicrop Area</td>
<td>537,240</td>
<td>963,330</td>
<td>426,090</td>
<td>79.3</td>
</tr>
<tr>
<td>Irrigated Crop Area</td>
<td>9,512,350</td>
<td>9,031,430</td>
<td>-480,920</td>
<td>-5</td>
</tr>
</tbody>
</table>

2. Solving for the irrigated land area for the remaining six regions:

   We made an assumption that the 160-98 2020 irrigated land area for those 6 regions each reduced by the same percentage to meet the target of 7,459,000 acres would be plausible as a 2030 level.

<table>
<thead>
<tr>
<th>Region</th>
<th>Statewide</th>
<th>Four regions</th>
<th>Six regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated Land Area</td>
<td>8,069</td>
<td>610</td>
<td>7,459</td>
</tr>
</tbody>
</table>

   7,459,000 acres need to be allocated to the 6 remaining regions.

   Each of the six regions 2020 irrigated land area would be reduced by 7.06% for a plausible 2030 level.

<table>
<thead>
<tr>
<th>Region</th>
<th>6 regions</th>
<th>6 regions target</th>
<th>6 regions</th>
<th>6 regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated Land Area</td>
<td>2020: 8,025</td>
<td>2030: 7,459</td>
<td>Change: -566</td>
<td>Change %: -7.06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2020 Irrigated Land Area</th>
<th>CC</th>
<th>SC</th>
<th>SR</th>
<th>SJ</th>
<th>TL</th>
<th>CR</th>
<th>Six Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>420</td>
<td>180</td>
<td>2,080</td>
<td>1,855</td>
<td>2,885</td>
<td>605</td>
<td>8,025</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2030 Irrigated Land Area</th>
<th>CC</th>
<th>SC</th>
<th>SR</th>
<th>SJ</th>
<th>TL</th>
<th>CR</th>
<th>Six Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>390</td>
<td>167</td>
<td>1,933</td>
<td>1,724</td>
<td>2,681</td>
<td>562</td>
<td>7,459</td>
</tr>
</tbody>
</table>
3. Solving for multicrop acreage for remaining six regions:

- Central Coast has an existing level of multicropping already higher than the B160-98 2020 level. It is at a very high level (the highest ratio of Multicrop/ILA of all regions).

- We made an assumption that the existing (2000) acreage of multicropping (166,000 acres) be used as the 2030 level for Central Coast.

- South Coast will be losing significant acreage of irrigated land area, of which some will occur in those areas where intensive multicropping occurs (Oxnard Plain). It is not plausible that multicropping could increase in South Coast. Current acreage is about 26,000 acres, 2020 had 10,000 acreage.

- We made an assumption that the 2020 level of acreage from B160-98 be used for South Coast.

- The Colorado River region has a high level of multicropping, will have some reduction in irrigated land area, and could make some increase. Current levels are about 103,000 acres, 2020 had about 145,000 acres.

- We made an assumption that the 2020 level of acreage from B160-98 be used for the 2030 level for Colorado River.

<table>
<thead>
<tr>
<th>2030</th>
<th>CC</th>
<th>SC</th>
<th>CR</th>
<th>1-3 Regions</th>
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</thead>
<tbody>
<tr>
<td>Multicrop Area</td>
<td>166</td>
<td>10</td>
<td>145</td>
<td>321</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2030</th>
<th>1-3 Region</th>
<th>Statewide</th>
<th>Difference</th>
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</thead>
<tbody>
<tr>
<td>Multicrop Area</td>
<td>321</td>
<td>968</td>
<td>647</td>
</tr>
</tbody>
</table>

- The three regions in the Central Valley (Sacramento River, San Joaquin River, and Tulare Lake), will need to have their multicropping acres sum to 647,000 acres.

<table>
<thead>
<tr>
<th>2000</th>
<th>2030 target</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multicrop Area</td>
<td>SR SJ TL 4-6 Regions</td>
<td>4-6 Regions</td>
</tr>
<tr>
<td>18 86 136 240</td>
<td>647</td>
<td>407</td>
</tr>
</tbody>
</table>

- 407,000 acres need to be added to the existing 2000 multicropping acreage in the Central Valley.

- We made an assumption that the 407,000 acres be allocated to the three regions based upon the percentage of their total irrigated land acreage at the 2000 level.
### 4-6 Regions

<table>
<thead>
<tr>
<th></th>
<th>SR</th>
<th>SJ</th>
<th>TL</th>
<th>4-6 Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated Land Area</td>
<td>1,933</td>
<td>1,724</td>
<td>2,681</td>
<td>6,339</td>
</tr>
<tr>
<td>Irrigated Land Area%</td>
<td>31</td>
<td>27</td>
<td>42</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>SR</th>
<th>SJ</th>
<th>TL</th>
<th>4-6 Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multicrop Area (2000)</td>
<td>18</td>
<td>86</td>
<td>136</td>
<td>240</td>
</tr>
<tr>
<td>Allocated acreage</td>
<td>124</td>
<td>111</td>
<td>172</td>
<td>407</td>
</tr>
<tr>
<td>Multicrop Area (2030)</td>
<td>142</td>
<td>197</td>
<td>308</td>
<td>647</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>NC</th>
<th>SF</th>
<th>CC</th>
<th>SC</th>
<th>SR</th>
<th>SJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated Crop Area</td>
<td>335</td>
<td>65</td>
<td>557</td>
<td>177</td>
<td>2,075</td>
<td>1,921</td>
</tr>
<tr>
<td>Multicrop Area</td>
<td>0</td>
<td>0</td>
<td>166</td>
<td>10</td>
<td>142</td>
<td>197</td>
</tr>
<tr>
<td>Irrigated Land Area</td>
<td>335</td>
<td>65</td>
<td>390</td>
<td>167</td>
<td>1,933</td>
<td>1,724</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>TL</th>
<th>NL</th>
<th>SL</th>
<th>CR</th>
<th>Statewide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated Crop Area</td>
<td>2,989</td>
<td>165</td>
<td>45</td>
<td>707</td>
<td>9,037</td>
</tr>
<tr>
<td>Multicrop Area</td>
<td>308</td>
<td>0</td>
<td>0</td>
<td>145</td>
<td>968</td>
</tr>
<tr>
<td>Irrigated Land Area</td>
<td>2,681</td>
<td>165</td>
<td>45</td>
<td>562</td>
<td>8,069</td>
</tr>
</tbody>
</table>

### Developing regional estimates of acreage of 20 individual irrigated crops:

Following are the five general assumptions made for this analysis:

1. The 2000 crop acreages were used as a starting point. By region, some or all of those individual acreages were modified.

2. The sum of each region’s individual crop acreages will be equal to the total irrigated crop acreage developed earlier.

3. The high value crop ratio must be equal to or greater than the 2000 level.

4. The low value crops will not be reduced by more than 50% in any region.

5. The multicrop ratio will range between the 2000 level and 0.36 (which is the highest level of all regions in 2000 - Central Coast).
### Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High value crops</strong></td>
<td>All truck crops, trees, and vines</td>
</tr>
<tr>
<td><strong>Low value crops</strong></td>
<td>Grain, rice, cotton, sugar beets, corn, safflower, dry beans, other field,</td>
</tr>
<tr>
<td></td>
<td>pasture, and alfalfa</td>
</tr>
<tr>
<td><strong>Potential multi crops</strong></td>
<td>Grain, corn, safflower, dry beans, other field, all truck crops</td>
</tr>
<tr>
<td><strong>High value crop ratio</strong></td>
<td>Sum of high value crop acreage divided by total crop acreage times 100</td>
</tr>
<tr>
<td><strong>Multicrop ratio</strong></td>
<td>Multicrop acres divided by the sum of potential multi crops acreage</td>
</tr>
<tr>
<td><strong>Maximum low value crop</strong></td>
<td>Reduction - A maximum of 50% reduction in low value crops can occur</td>
</tr>
</tbody>
</table>

### Rules for determining the individual crop acreages for each region:

Steps 1 through 7 are all for adjusting individual crop acreage to meet the high value crop ratio requirements.

1. Determine the change in total crop acreage between 2000 and 2030.
   - If the change is positive (2030 greater than 2000), go to 2.
   - If the change is negative (2000 greater than 2030), go to 5.

2. Determine the percentage of high value crops for 2000 level.
   - If the high value crop percentage is less than 10%, go to 3.
   - If the high value crop percentage is greater than 10%, go to 4.

3. Increase all crops by the same percentage, go to 10 (to evaluate multicrop ratio - high value crop ratio OK).

4. Increase the high value crops by the same percentage, go to 10 (to evaluate multicrop ratio - high value crop ratio OK).

5. Reduce the level 2000 low value crops by the same percentage and keep the high value crop acreage the same as 2000.
   - If the required reduction in low value crops is less than 50%, go to 10 (to evaluate multicrop ratio - high value crop ratio is OK).
   - If the required reduction in low value crops is more than 50%, go to 6.

6. Reduce the amount of low value crops equally by 50% from 2000 level. The remaining required reduction will be taken from the 2000 level high value crops equally using the same percentage.
- If the high value crop ratio is equal to or greater than the 2000 level, go to 10 (to evaluate multicrop ratio - high value crop ratio is OK).

- If the high value crop ratio is less than the 2000 level, go to 7.

7. Increase the high value crops and reduce the low value crops by the same amount so that the high value crop ratio is at the 2000 level. Go to 8 (to evaluate multicrop ratio - high value crop ratio is OK).

Steps beginning with 8 are all for adjusting individual crop acreage to meet the multicrop ratio requirements.

8. Determine if the multicrop ratio is between the 2000 level and a maximum level of 0.36.

- If the multicrop ratio is between the 2000 level and 0.36, the results are final.
- If the multicrop ratio is greater than 0.36, go to 9.
- If the multicrop ratio is less than the 2000 level, go to 10.

9. Increase the potential multi crops and decrease the remaining crops so the multicrop ratio is 0.36.

- If the high value crop ratio is equal to or greater than the 2000 level, the results are final.

10. Decrease the potential multi crops and increase the remaining crops so the multicrop ratio is the 2000 level.

- If the high value crop ratio is equal to or greater than the 2000 level, the results are final.
- If the high value crop ratio is less than the 2000 level, then stop.
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By Jan S. Stevens
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University of California at Davis, June 9, 2004

Applying the Public Trust Doctrine to River Protection

Jan S. Stevens

The public trust is an ancient doctrine, stemming from Roman law. The Institutes of Justinian state that “by natural law, these things are common property of all: air, running water, the sea, and with it the shores of the sea.” In medieval England this notion was picked up and turned into a declaration that the shores of the sea are common to all and inalienable. The concept was adopted in the United States. As early as 1821, a New Jersey court held that the state could not convey into private ownership the public lands covered by tidal waters, and that any grant purporting to do so was void. These waters are vested in the sovereign state, the court held, not for its own use, but for the use of its citizens for “passing and repassing, navigation, fishing, fowling, sustenance, and all the other uses of the water and its products...” Arnold v. Mundy, 6 N.J.L. 1 (1821). Although the legislature may build dams, locks and bridges in the general interest of improving navigation, the court stated, “they may not consistently with the principles of the law of nature and the constitution of a well-ordered society, make a direct and absolute grant of the waters of the state, divesting all the citizens of their common right.” That, said the Chief Justice, would be a grievance “which never could be long borne by a free people.” Id at 78.

The public trust, like the ten commandments, has traditionally been phrased in terms of prohibition: “Thou shalt not abdicate the State’s control over its navigable waters.” More recently, however, this hoary common law creature, with roots in the civil laws of the Roman emperors, the English monarchs and the Spanish kings, has emerged from its long submerged home to impose new protections for the environment and new duties on governmental agencies.

1. **The trust applies to all navigable streams.**

Historically, the trust protected largely commercial purposes related to commercially navigable waters. It was characterized in terms of “commerce, navigation and fishery.” In recent years, however, courts in California and elsewhere began to acknowledge that the doctrine was not “burdened with an outmoded classification favoring one mode of utilization over another.” Trust rights were not limited to commercially navigable streams, but applied also to streams capable of use by small boats, for such purposes as bathing and swimming, fishing, hunting and general recreational purposes, as well as preservation for ecological study. Marks v. Whitney, 6 Cal.3d 251 (1971); Baker v. Mack, 19 Cal.App.3d 1040 (1971).
At the same time, they recognized the logic of extending the trust to the *tributaries* of navigable streams, for taking the water from these feeder streams would inevitably impact the trust resources below them. National Audubon Society v. Superior Court, 33 Cal.3d 419 (1983); see Johnson, Public Trust Protection of Lake and Stream Levels, 14 U.C. Davis L. Rev. 233 (1981).

2. **The trust applies to ecological preservation.**

In *Marks v. Whitney*, the California Supreme Court noted: “The public uses to which tidelands are subject are sufficiently flexible to encompass changing public needs...There is a growing public recognition that one of the most important public uses of the tidelands— a use encompassed within the tideland trust—is the preservation of those lands in their natural state, so that they may serve as ecological units for scientific study, as open space, and as environments which provide food and habitat for birds and marine life, and which favorably affect the scenery and climate of the area.” Of course the courts have long recognized that the trust extends equally to non-tidal inland waters. State v. Superior Court (Lyon) 29 Cal.3d 210 (1981).

3. **The trust has crawled out of the depth and applies to wetland areas.**

Once out of the perpetual depths, the trust has moved to the high water line and beyond on our lakes and rivers. As public trust uses were recognized as encompassing picnicking, fishing and other kinds of recreation, it became clear that these uses were protected to the high water marks of lakes and rivers, even if these areas were temporarily dry. Thus in an informal opinion in 1992, then Attorney General Dan Lungren advised that they could e exercised even on dry portions of the South Fork of the A The American River. Letter to Hon. David Knowles, Op. No. 92-206 (June 15, 1992). And the Montana courts have recognized a wide range of upland activities permissible under the public trust doctrine. Montana Coalition v. Curran, 682 P.2d 163 (Mt. 1984).

Once it was acknowledged that the public trust protected aquatic ecology as well as navigation, courts began to comprehend the connection between the waters and the wetlands. In *Just v. Marinette County*, 201 N.W.2d 761 (Wis. 1972), the Wisconsin Supreme Court upheld building restrictions on the adjacent foreshore because “the State of Wisconsin under the public trust doctrine has a duty to eradicate the present pollution and to prevent further pollution in its navigable waters. The active public trust duty of the State...in respect to navigable waters requires the state not only to promote navigation but also to protect and preserve these waters for fishing, recreation, and scenic beauty...Lands adjacent to or near navigable waters exist in a special relationship to the state. They ...are subject to the state public trust powers (citation)...The shoreline zoning ordinance preserves nature, the environment, and natural resources as they were created and to which the people have a present right.” Id at 771. See, also, Graham v. Estuary Properties, Inc. 399 S02d. 1374, (Fla. 1981)(no absolute right to change natural character of land).

4. **The trust goes underground.**


Once logic held sway and the trust was applied to tributaries of recreationally navigable waters, it seemed logical to apply it as well to groundwater supplying those waters and their accompanying trust uses. The Supreme Court of Hawaii had no trouble doing so in Waiahole decision in 2000. 94 Hawaii 97, 9 P.3d 409 (2000); see Symposium, Managing Hawaii’s Public Trust Doctrine, 24 U. of Hawaii L. Rev. 1 (2001). It rejected the “surface-ground dichotomy” as an “artificial distinction neither recognized by the ancient system nor borne out in the present practical realities of this state.” Id, 9 P.3d at 447.

California is almost alone in failing to regulate groundwater by permit. However the courts have protected surface streams against ground water pumping in private litigation, and the Attorney General has the power to institute litigation to control groundwater use on the ground that it constitutes waste, unreasonable use or method of use or violates the public trust. See Sax, We Don’t Do Groundwater: A Morsel of California Legal History, 6 U. of Denver Water Law Rev. 269, 309, 3113-314 (2003).

5. The trust applies to artificially enlarged waters.

Few lakes and rivers in California have escaped the improvements wrought by dams and levees. Few are in their natural state. Recognizing the reality of the situation, courts have invariably held that the additional areas artificially inundated are subject to the trust just as was the original bed as it existed at California’s statehood. State v. Superior Court (Fogerty) 29 Cal.3d 240 (1981); Big Bear Lake, created by a 1911 impoundment, was assumed to be navigable and thus a trust water, but the court declined to modify diversions because a responsible government body had weighed the competing uses. Big Bear Municipal Water Dist. v. Bear Valley Mutual Water Co., 207 Cal.App.3d 363 (1989). But another appellate court reached a different conclusion in Golden Feather Community Ass’n v. Thermalito Irrigation Dist., 199 Cal.App.3d 402 (1988) (no duty to maintain levels for fish in wholly non-navigable, artificial reservoir).

6. The trust applies to ferae naturae.

Wild creatures are protected by the trust. “[I]t is well settled that wild animals are not the private property of those whose land they occupy but are instead a sort of common property whose control and regulation are to be exercised ‘as a trust for the benefit of the people.’” Mountain States Legal Foundation v. Hodel, 799 F.2d 1423 (10th Cir. 1986) quoting Geer v. Connecticut, 161 U.S. 519, 528-529 (1896), overruled on other grounds, Hughes v. Oklahoma, 441 U.S. 322 (1970); see Ex parte Maier; People v. Truckee Lumber Co.
7. **The trust imposes duties on government.**

In the historic Mono Lake decision, the California Supreme Court applied a rule previously suggested by a number of other courts: The trust is not merely a passive doctrine, but there is an “affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible.” “Unnecessary and unjustified harm to trust interests” should be avoided. National Audubon Society v. Superior Court, 33 Cal.3d 419, 446-447 (1983), cert. denied 454 U.S. 977 (1983). See United Plainsmen v. North Dakota Water Conservation Com’n., 247 N.W.2d 457 (N.D. 1976).

The California court made it clear, however, that the test to be applied in water rights is not as stringent as that applicable to attempted alienation of the beds of navigable waters. It acknowledged that the Legislature may “as a matter of current and historical necessity...authorize the diversion of water to distant parts of the state, even though unavoidable harm to trust sues at the source stream may result.” Id 33 Cal.3d at 446.

This distinction proved crucial in EDF v. EBMUD, Alameda County Superior Court No. 425955, in which Judge Richard Hodge rejected the argument that EBMUD should be required to choose a different diversion point on the Sacramento River because it would be a feasible means of avoiding alleged harms to trust values in the Lower American. Construing Audubon as a direction “to balance and accommodate all legitimate competing interests in a body of water,” he concluded that imposition of a physical solution limiting EBMUD’s withdrawals would adequately protect trust values while accommodating EBMUD’s long deferred contract rights and concerns over water quality. The Hodge decision struggles with Audubon’s direction to take the public trust into account and protect public trust uses consistently with the “fullest beneficial use” provisions of Article X, section 2 of the California Constitution, and concludes that such reconciliation does not require “precise adjudication” in this case because both interests can be accommodated by limitation of diversions.

Thus it is still unsettled whether the application of the public trust to water rights imposes an additional mandate or merely a “hard look.” However the Audubon court expressly rejected a sate argument that the constitutional reasonable and beneficial use provisions had “subsumed” the public trust, and the State Water Resources Control Board has adopted regulations providing for its application in water rights proceedings.

8. **The trust may be implemented by statute.**

Since the Legislature is the ultimate trustee for the people, it can appropriately implement the trust by statute, and has done so in a number of cases. For instance, Fish and Game Code sections 5937 and 5946, requiring respectively that fish below dams be kept in good condition, and mandating that East Sierra water permits be so conditioned, was held by the Court of Appeal to be “a specific legislative rule concerning the public trust.”
Trout, Inc. v. State Water Resources Control Board, 207 Cal.App.3d 585, 630-631 (1989). Judge Karlton of the federal district court held some years ago that section 5937 applied to releases from Friant Dam that impacted fish in the San Joaquin River. And Judge Hodge in his EDF decision agreed with the State Department of Fish and Game that Public Resources Code section 5093.50, stating the state’s policy under the Wild and Scenic Rivers Act, was “a directive to preserve public trust values and thus a codification of the State’s public trust authority.” Statement of Decision 44.

Will we reach the stage where courts will hold that a statute “subsumed” the trust and adherence to it is adequate compliance with trust responsibilities? Recently the State Water Resources Control Board found that compliance with Water Code section 1736, permitting approval of a long-term transfer if the Board finds the transfer will not result in substantial injury to any legal user of water and will not unreasonably affect fish, wildlife, or other instream beneficial uses. Accordingly, the Board concluded, it was not necessary to make specific public trust determinations on application of the public trust doctrine to a long term transfer of water from the Imperial Irrigation District to San Diego, and its effects on the Salmon Sea.

9. The public trust paves the way to the waters.

In New Jersey particularly, the courts have been ready to make the public trust a ground for mandating public access over municipally owned lands to the beaches. As a New Jersey judge observed: “[T]o say that the public trust doctrine entitles the public to swim in the ocean and to use the foreshore in connection therewith without assuring the public of a feasible access route would seriously impinge on, if not effectively eliminate, the rights of the public trust doctrine.” Matthews v. Bay Head Improvement Assn., 471 A.2d 355, 364 (N.J. 1983), cert. denied, 469 U.S. 821 (1984)\(^1\).

California has maintained the traditional view that there is no right of passage over private lands to the waters. Bolsa Land Co. v. Burdick, 151 Cal. 254 (1907). Most courts have upheld portage as an incident of navigation, and a number have provided for public use of the foreshore (the dry sand area above high tide line) to fish, draw nets and the like. Moore & Moore, Fisheries 96 (1903). Massachusetts has taken the opposite view, Opinion of the Justices, 313 N.E.2d 561 (Ma. 1974); cf. Note, Waters and Watercourses—Right of Public Passage Along Great Lakes Beaches, 31 MICH. L. REV. 1134, 1138-1142 (1933).

However consistent with the ancient maxim that there is more than one way to skin a cat, California acknowledges the common law doctrine of implied dedication to provide access

\(^1\) The beach is traditionally divided into three separate areas. The area from the sea to the ordinary highwater mark is known as the foreshore or tideland, form the ordinary highwater mark to the vegetation of debris line is known as the dry sand area, and landward from the vegetation line is considered private upland. Slade, Putting the Public Trust Doctrine to Work xxxix-xl. (1990).
to the waters over routes long permitted by the landowner, Gion v. City of Santa Cruz, 2 Cal.3d 29 (1970) and a number of statutes require public access as a condition of developing land. E.g., Public Resources Code sections 30530-30214; Government Code sections 66478.1 et seq; see Kern River Public Access Committee v. City of Bakersfield, 170 Cal.App.3d 1205 (1985).

The California holdings have been influenced by its constitutional provision instructing the legislature to assure that frontage and tidal lands of all navigable waters remain open and accessible to its residents. In People v. El Dorado County, 96 Cal.App.3d 403 (1979), this provision added a constitutional dimension to the right to navigate. In Lane v. City of Redondo Beach, 49 Cal.App.3d 251 (1975) it guided a decision prohibiting the vacating of a city street that would have destroyed public access to the beach. And in Dietz v. King, 2 Cal.3d 29 (1970), the companion case to Gion, the California court noted the “strong policy expressed in the constitutions and statues of this state of encouraging public use of shoreline recreational areas,” and said these provisions “clearly indicate we should encourage public use of shoreline areas whenever that can be done consistently with the federal constitution.”

Recently, principle of access was applied to overflights of trust lands. Ken Adelman, a successful retiree, undertook to photograph California’s entire coastline from his helicopter and post images free on the web. The more than 12,000 images he posted are on www.californiacostline.org. According to newspaper accounts, the project documented illegal sea walls, sewage outflows, erosion and masses of new development. It also depicted Barbra Streisand’s hilltop Malibu estate. Streisand filed a lawsuit demanding that the photo depicting her house be removed, along with the caption reading “Streisand Estate, Malibu.” Noting the public interest in the California shorezone and the minimal nature of the alleged invasion of privacy, Los Angeles judge Allan J. Goodman ruled against her.

10. The trust is available to any member of the public.

The public trust doctrine avoids the irksome and sometimes disastrous struggles over standing available in actions under other statutes and doctrines. The Marks v. Whitney decision made it clear that it is available any member of the general public, because it involves a right to which any member of the public is entitled.

11. The federal government is subject to the trust, or is it?

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2 Cal Const. Art X, sec. 4 provides in part: “No individual, partnership or corporation...shall be permitted to exclude the right of way to such water whenever it is required for any public purpose...and the Legislature shall enact such laws as will give the most liberal construction to this provision, so that access to the navigable waters of this State shall always be attainable for the people thereof.”
Generally the federal government has resisted efforts to impose the public trust on it. The influential District of Columbia circuit declined to consider the question in District of Columbia v. Air Florida, Inc., 750 F.2d 1077 (D.C. Cir. 1984). However a federal district court in California suggested that a trust-like duty lay with the Department of the Interior to protect national parklands from adjacent activities. Sierra Club v. Dept. of the Interior, 376 F.Supp. 90 (N.D. Cal); Sierra Club v. Andrus, 487 F.Supp. 443. Cf. Alabama v. Texas, 347 U.S. 272, 273 (1954): “The United States holds [such] resources...in trust for its citizens in one sense, but not in the sense that a private trustee holds for [a beneficiary]. The responsibility of Congress is to utilize the assets that come into its hands as sovereign in the way that it decides is best for the future of the nation.”

A recent article eloquently argues for application of the public trust doctrine in the exclusive economic zone. Jarman, The Public Trust Doctrine in the Exclusive Economic Zone, 65 Oregon L. Rev. 1 (1986). If, as courts have consistently stated, the trust is an inherent attribute of sovereignty, the United States as the only sovereign out there would seem to be subject to it.

**Conclusion**

Justice Holmes many years ago sustained the rights of a state to prohibit diversions from a river against the admitted property rights of a water company, saying:

> Few public interests are more obvious, indisputable and independent of particular theory than the interest of the public of a State to maintain the rivers that are wholly within it substantially undiminished, except by such drafts upon them as the guardian of the public welfare may permit for the purpose of turning them to a more perfect use. The public interest is omnipresent wherever there is a state, and grows more pressing as population grows. It is fundamental, and we are of opinion that the private property of riparian proprietors cannot be supposed to have deeper roots...The private right to appropriate is subject not only to the rights of lower owners but to the initial limitation that it may not substantially diminish one of the great foundations of public welfare and health. Hudson County Water Co. v. McCarter, 209 U.S. 349, 356 (1908).
Considering Water Use Efficiency for the Environmental Sector

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May 14, 2004
Acknowledgements

We would like to thank the Department of Water Resources and the State Water Plan Public Advisory Committee for giving us the opportunity to explore this issue. We thank Professors Margaret Taylor and Eugene Bardach for providing helpful comments and suggestions. We also wish to express our appreciation to Gary Bobker, Nick DiCroce, Anisa Divine, Jay Lund, Jennifer Martin, and B.J. Miller, who took the time to discuss this issue with us and explain their points of view. Finally, we are especially grateful to John Andrew and Michael Perrone for the time and attention they devoted to this project.
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The authors of this report are masters students at the Goldman School of Public Policy at the University of California, Berkeley, and this report fulfills the course requirements of Public Policy 200. The opinions expressed in this report are those of the authors and do not necessarily represent those of the Goldman School, the University of California, or the Department of Water Resources. This study was prepared in conjunction with the 2003 update of the California Water Plan.
Executive Summary

The goal of this report is to provide a starting point from which the water planning community can move toward improving the allocation of water within the environmental sector. To facilitate that process, this report presents:

1. A discussion that highlights the water community’s points of agreement on the concept of analyzing the application of water to the environment
2. A term, Managed Environmental Water Use Efficiency (MEWUE), to reflect that concept, and a definition of that term
3. A survey of existing methods that could be used to develop MEWUE
4. Suggestions about how to proceed with implementing MEWUE

Based on our analysis, we found that there was genuine interest in understanding and improving how water is allocated to the environment. The idea of maximizing environmental benefits for a given amount of allocated water is a unifying thread among stakeholder interests. We focus on this idea throughout the report as the central concept that MEWUE is intended to achieve.

We propose a new term to reflect the stated concerns of stakeholders that other terms, Environmental Water Use Efficiency and Ecosystem Restoration Water Use Efficiency, did not fully address. We propose Managed to indicate that MEWUE does not evaluate the environment’s use of water per se but rather the effectiveness of water in controlled systems. We propose Environmental to reflect the range of “uses” of water in the ecosystem, including ecosystem maintenance, restoration, and water quality. Lastly, we support the use of the word Efficiency because efficiency communicates the intent of maximizing benefit for a given amount of water, providing a basis for comparison of the benefits obtainable from different uses of that water.

MEWUE: a mechanism to analyze alternative uses of managed environmental water to determine which allocation of a given amount of water will maximize environmental benefits, and a means to improve decision-making over time.

We address the issue of why having an explicit decision-making mechanism is essential. It is hard to allay the fears that some have of incorrectly measuring environmental benefits. However, it is even more difficult to claim that decisions based on implicit measures and beliefs are better for the environment than those based on some imperfect but explicit consideration of environmental benefits.

The new term, MEWUE, and its definition can place stakeholders on the same page. There will be less confusion about what WUE for the environment means and is intended to accomplish. This common ground will allow the investigation of methods to implement MEWUE to move forward.

In addition to outlining a concept, this report explores existing approaches that could play a part in implementing MEWUE. The methods researched fall under two major categories: metrics of ecosystem quality and institutional improvements. Each technique described includes a case study to highlight its implementation and applicability to MEWUE. The metric techniques discussed are:
Ecological Indicators
Instream Flow Requirements
Economic Valuation

The institutional techniques discussed are:

- Benchmarking and Best Management Practices
- Improved Water Management and Collaboration

The two broad categories of methods will probably work best in combination with each other. The technical approaches offer a method for calculating changes to the environment, while the institutional methods are necessary to operationalize the technical methods.

This report suggests further investigation of MEWUE. Our analysis finds that there is enough common ground among stakeholders to warrant further development of MEWUE. Furthermore, there are techniques already in practice that promote the goal of MEWUE and that can potentially serve as methods for successful MEWUE implementation. We hope that this report provides sufficient direction to begin an on-going collaborative process of defining and implementing MEWUE that continually improves the allocation of water within the environmental sector.

Main Conclusions

Maximizing the environmental benefits for a given amount of water is a valuable concept for the California water planning community to pursue. MEWUE is a feasible way to implement this concept. Various techniques applicable to assessing and improving MEWUE are in place or are being developed and could feasibly be adapted for use in a specific MEWUE program.

This report is the first step in a process. We hope it can serve to start a collaborative discussion among stakeholders on how to best implement MEWUE.
1.0 Introduction

Background

Water planning in California has historically been a technically and politically complex process, with many diverse stakeholders vying for access to a limited resource. In the past, the water planning process focused on the agricultural and urban water use sectors. Water scarcity affected these sectors as California grew, which prompted development of efficiency measures to address the problem.

Some believe that it is now time to evaluate whether the environmental sector can and should use its water resources more efficiently. Some stakeholders in California water management believe that since understanding of ecosystem health is improving, opportunities are emerging to enable maximizing overall environmental benefits from any given amount of expenditures – whether in monetary or water terms. Since resources for environmental uses are becoming scarcer as compared to the recent past, policymakers increasingly face the need for a method of evaluating the relative environmental benefits of alternative uses of these resources.

Certain water interests believe that water used for environmental purposes should be held to an efficiency standard similar to those in agricultural and urban sectors. However, some members of the water planning community oppose the idea of implementing water use efficiency (WUE) measures for the environmental sector. Reasons for this resistance vary among stakeholders, but we characterize their concerns broadly to include: a fear that implementing such measures will ultimately take water away from environmental uses; reluctance to put a price on something that some believe should not (and cannot) be valued; and the belief that such measures in the environmental context are inappropriate since some believe the goal of water use efficiency should be to keep as much water in the environment as possible.

To date, there is no consensus about whether or not to pursue the development of such an efficiency standard and how to approach its implementation framed the analysis in this report.

In addition to this lack of consensus between groups, problems also arise regarding the technical feasibility of implementing WUE for the environmental sector. A major barrier to the process is the perceived lack of both a comprehensive way to measure the health and/or value of ecosystems and a method of comparing the relative benefits of alternative water uses. Whether expressed as a single value or as an index of several relevant factors, measuring ecosystem health suggests the use of some quantitative metric of ecological integrity. Such a metric may need to incorporate such diverse factors as chemical water quality, biological species populations, and physical channel structure. Implementing efficiency standards would ideally involve a systematic way to compare the relative benefits of alternative water uses based on these measures of ecosystem health. Developing these methods is a daunting task and leads some to reject this approach due to the difficulties involved.

The lack of consensus about whether or not to pursue the development of such an efficiency standard and how to approach its implementation framed the analysis in this report.
Context of Analysis

We performed this analysis at the request of the Statewide Water Planning Branch of the Department of Water Resources (DWR). DWR is required by statute to provide updates to the California Water Plan every five years, and is currently developing the next version of the update. The Update includes descriptions of “statewide water supplies, water uses, and actions that could be taken by water agencies to improve future water supply reliability.” There have been requests that the next Update address the concept of efficiency for environmental water use, and DWR perceived the need to obtain an independent analysis of the topic given the state of contention among stakeholders about the concept.

DWR works with a statewide Public Advisory Committee that provides input to the preparation of the Water Plan Update. Advisory Committee membership “is intended to represent a diverse cross-section of water use and water management interests, with broad geographic distribution from throughout California.” The state’s primary water interests make up the committee – including agricultural interests, state and federal agencies, environmental groups and urban water districts.

Methodology

We began our analysis by developing a standard questionnaire that we used as the basis for interviews with targeted representative stakeholders. Questions focused on the stakeholders’ role in state water planning, their current understanding of the concept of WUE as applied to the environment, examples of inefficiency in environmental water use, and suggestions for how to facilitate the improvement of water use efficiency in the environmental sector. From a list of those interested in participating, we interviewed Advisory Committee members that represent the main sectors of water use planning. These interviews provided valuable information and perspectives that we have made use of in this report; however, we have refrained from citing specific conversations or people.

We then conducted a literature review that aimed to investigate measures of efficiency currently used for environmental purposes that may help develop a concept of WUE for the environmental sector in California. This research included ecosystem performance indicators, ecosystem services valuation, urban and agricultural water use efficiency history and measures, legal and regulatory concerns, and other relevant topics.

Next, as subsequent sections of this report describe, we chose a term and developed a definition that address stakeholders’ interests and can serve as a starting point from which to further develop a more complex definition of efficiency. We also developed and evaluated alternative approaches to implement this concept. During the course of our analysis we recognized that these alternatives function more effectively as interrelated components of our definition of efficiency than as stand-alone alternatives from which water planners must choose.

3 See Appendix A for a list of the full Advisory Committee.
4 See Appendix B for the list of interview questions used.
5 See Bibliography for names of those interviewed.
Scope

Our analysis focused on two main issues: whether and how to assess the relative efficiency of water use for environmental purposes in California. Interviews with stakeholders and an evaluation of current water allocation practices led us to respond affirmatively to the first issue, and to further pursue the second. Therefore, this report develops the concept of WUE within the environmental sector, and introduces a term that all stakeholders can agree on to describe that concept. We also investigate potential implementation strategies for improving efficiency, as defined in this report. We aim to provide a starting point from which progress can be made on this issue, as well as provide suggestions on how to proceed.

Our analysis is directed strictly towards the environmental sector, and the goal of maximizing environmental benefits from a given amount of water dedicated to that sector. We do not address WUE in the agricultural or urban sectors, and our results are not intended to draw a comparison to those sectors. While we recognize that some stakeholders desire such inter-sector comparisons, environmental benefits are not sufficiently quantifiable (as discussed above) to allow these direct comparisons.

2.0 The Rationale for MEWUE

While WUE is being applied in urban and agricultural contexts, some stakeholders feel it is not a useful term or concept for environmental applications. In this section we forecast and assess the merits of the likely outcomes if the water planning community chooses to disregard this concept and continue current planning practices. In so doing, we briefly describe current decision-making practices for allocating water to the environment. We demonstrate why, in our view, current practice in the environmental sector highlights the need for a more explicit consideration of WUE and in fact is already moving in this direction in an ad hoc fashion.

We then present a term to address the concept of WUE with respect to the environment. We explain how this concept can benefit the environment and promote wise water use planning.

2.1 Present Trends in Management of Environmental Water

Description of Current Practice

Most current environmental water planning decisions are driven by regulatory compliance, not directly by efficiency or environmental benefits. An example of this phenomenon is the effort to meet the Delta salinity requirement in 2003, discussed as a case study below. In general, environmental regulation has provided and continues to provide valuable mechanisms for environmental improvement. However, many regulations themselves are created in response to a crisis and thus are tailored to that specific issue. This leads at times to an inappropriate focus on specific species or components of environmental quality. For example, state and federal endangered species legislation has been an effective mechanism for procuring water for the environment. This legislation motivates action on behalf of the listed species, which may or may not effectively address the needs of ecosystems as a whole.

Given a system of regulation and decision-making that is in large part reactive to crisis, science is often not as critical a component of environmental water use decisions as some desire. Policymakers are rarely in a position to make a considered evaluation of the tradeoffs involved with using water for alternative environmental applications. There is no office or organization serving as a clearinghouse for making comparative judgments of the benefits derived from various projects.
Many stakeholders stress the importance of adaptive management. Adaptive management is, generally, a practice of “learning by doing,” or of evaluating the performance of past successes and failures and applying the insights gained to future projects. While some organizations are practicing adaptive management, this approach is not being fully implemented on many projects. CALFED has recently issued an evaluation of its Ecosystem Restoration Program (ERP) that specifically lists improving the process of “learning by doing” as one of its key recommendations. No specific mechanism exists to mandate or encourage adaptive management across organizations. We discuss adaptive management further in this report, particularly in section 3.2.1.

Accountability for the satisfactory environmental performance of projects is currently established through policymakers’ scrutiny of dollars and quantities of water spent. Some stakeholders feel that this mechanism is an appropriately rigorous screen. Others feel that this level of accountability is insufficient and weaker than that established by WUE standards in the urban and agricultural sectors.

Many organizations involved with environmental water planning or ecosystem restoration in California are pursuing innovative, evaluative methods. For example, the Bay Institute has developed a Scorecard that grades the ecological condition of San Francisco Bay using eight different science-based indicators. The Nature Conservancy has developed Conservation by Design, a framework for selecting conservation goals and measuring the success of its efforts. We discuss additional examples as case studies in later sections of this report. Other organizations are recognizing a need for a more systematic approach to assessing the success of their efforts. CALFED’s recent evaluation of its ERP calls for greater efforts to evaluate the performance of projects.

Case Study 1

The X2 Salinity Standard and the Strand of the 2003 Salmon Hatch

The Bay-Delta Accord (1994) and the resulting Water Quality Control Plan (1995) established the X2 standard to control the penetration of salt water into the Delta estuary. X2 sets a minimum distance, in kilometers, from the opening of the Golden Gate to the point at which the salinity of the Delta is two parts per thousand. In order to maintain X2 at various seasonal values, water planners must manage...
freshwater diversions upstream of the Delta to ensure that sufficient fresh water is available to flush the Delta. These seasonal distances are set to ensure the survival of several aquatic species, notably the delta smelt and longfin smelt.\textsuperscript{12}

In 2003, unusually light winter precipitation created low flow conditions into the Delta. In response, the Bureau of Reclamation released 300,000 acre-feet of water from Folsom Dam on the American River in order to maintain X2 compliance. The high flow conditions on the American persisted for a few days until the extra releases were shut off. During the high-flow period, salmonids laid eggs high on the banks of the river. The subsequent flow reduction stranded these eggs on the riverbank.

These events destroyed much of the 2003 salmon spawn. Moreover, the early release from Folsom Dam meant that this water was not available later in the season, when it would otherwise have been released. These releases, in normal years, provide sufficient water to downstream users to allow the curtailment of pumping from the Delta while young salmonids are passing through on their way to the ocean. Due to the early Folsom Dam release, 300,000 fewer acre-feet of water were available in 2003 to supplant curtailed pumping, so the pumps were run more frequently during the salmonid migration. This further diminished the salmon population. The benefit gained by this series of events was maintaining the X2 standard and averting damage to the smelt and other Delta species.

Several stakeholders we spoke with saw this series of events as an example of inefficient use of environmental water. They felt that the harm caused by the strand of the salmon hatch and the loss of export curtailments outweighed the benefit to the Delta ecosystem gained by meeting the X2 requirement. They argue that there must have been a way to reallocate the available water to produce greater net environmental benefit. However, stakeholders did not agree on the source or explanation of this inefficiency, or on the characteristics of a superior solution. Some felt that the problem was the specific, inflexible standards set by the X2 regulation, and argued that the regulation itself led directly to inefficiency. The solution, in their minds, was to increase regulatory flexibility by allowing selective noncompliance with X2 when compliance would produce undesirable results such as these. Others viewed the situation as a product of bad management decisions, rather than inflexible regulation. They argue that a large short-term release from Folsom Dam was not the only or the best way to ensure compliance with X2, which is an important component of the health of the Delta. In their view, other management options may have existed\textsuperscript{13} that would have maintained X2 compliance while avoiding a significant impact on the salmonid population.

This case study illustrates a number of salient features of the current process of environmental water use decision-making. A short-term crisis and a regulation were central drivers of water allocation. The decision-making process did not directly involve scientific or economic analysis of the tradeoffs between different potential actions or the environmental benefits that would accrue in different scenarios. Agencies made an isolated decision based on a single criterion instead of addressing holistic ecosystem needs. The existing systems of management, according to some, were not sufficient to handle the issue optimally.

\textsuperscript{13} For example, managers could have released water more slowly from Folsom Dam, or released water from other dams as well.}
Discussion of Projected Outcomes if Current Trends Continue

Absent the introduction of a water use efficiency approach, we can expect the scene going forward to look much like what we have described above. Some stakeholders would be pleased with this outcome, and see no need for a new paradigm. Others would be disappointed, particularly those desiring greater accountability for the benefits achieved by dedicating water to the environment and those who wish for a better way to understand benefits of water use in the environmental sector. Water managers will continue to make decisions principally on the basis of issues other than direct maximization of environmental benefits, as discussed above. While some organizations are employing some form of adaptive management, there is no cross-organizational mechanism to ensure such practices.

It would be erroneous and dismissive to suggest that current ecosystem restoration practice is static and does not provide the potential for environmental water use to become more efficient. Indeed, many organizations are moving towards innovative processes that hold plenty of promise in further integrating science, adaptive management, and ecosystem performance indicators. Again, CALFED’s ERP project evaluation is a good example, and specifically recommends increased use of these practices. So, even without formally implementing a WUE approach, we would expect progress towards efficient water use. Many stakeholders see these practices as distinct from an efficiency concept. However, we see these ideas as potential methods to implement WUE, as we will later discuss. The fact that different organizations are recommending similar measures for improving water use suggests a setting ripe for systemic improvement. Section 3 of this report discusses these methods and ideas for how they can be pursued more comprehensively.

2.2 The MEWUE Concept and Terminology

Agreement on a Central Concept

Though common perception is that there is much disagreement about WUE for the environment, all of the stakeholders that we interviewed for this project agree that water planning should try to maximize the environmental benefits obtainable from a given amount of water that is dedicated to the environment. This concept, in our opinion, is the foundation for defining WUE for the environmental sector. The obvious challenge is how to go about measuring or evaluating these benefits. We will discuss some potential methods to measure benefits in section 3 of this report, and we will make some recommendations about how to proceed. The method of evaluating benefits will be critical to some stakeholders’ ultimate acceptance of the approach. However, providing consensus on a central concept and engendering acceptance of the need for WUE in the environment will set the basis for a more responsive discussion about how to measure benefits. Therefore, we first seek to attach a term to this concept that best captures what it is trying to accomplish. We propose Managed Environmental Water Use Efficiency (MEWUE).

MEWUE: a mechanism to analyze alternative uses of managed environmental water to determine which allocation of a given amount of water will maximize environmental benefits, and a means to improve decision-making over time.

Discussion of MEWUE as the Chosen Term

The initial term proposed by those considering this concept was Environmental WUE. Subsequently, others proposed Ecosystem Restoration WUE as a potentially superior term. In addition, some suggested effectiveness in place of efficiency. Different parties we spoke with had concerns with each of these
terms. We considered the relative merits of alternative terms and found that MEWUE works the best to capture the ideas on which stakeholders agreed.

The benefit of using the term Environmental WUE is that it is a comprehensive descriptor and clearly represents the third major sector of water use. However, this term can be interpreted to mean that the goal of implementing WUE is to evaluate the returns on the environment’s use of water in its natural state. The true goal of WUE with regard to the environment, as expressed by stakeholders and the Department of Water Resources (DWR), is to evaluate the returns on water specifically devoted to the environment by humans.

Ecosystem Restoration WUE successfully narrows the issue to how humans use water for ecosystem restoration. However, this term may be overly specific and would leave out activities our concept is intended to encompass, such as ecosystem maintenance. Furthermore, some feel the term implies that there is a goal to restore ecosystems to a pre-existing and unspecified state, and are uncomfortable with this connotation.

We propose the term “Managed Environmental WUE” as a way to resolve the concerns described above. The term “Managed” excludes the possibility of evaluating the returns of water in its natural state, clarifying that only waters subject to human management are being considered. Including “Environmental” rather than “Ecosystem Restoration” allows a broader application of the term to include other activities as well as restoration.

Another issue that arose from our discussions with stakeholders on terminology and from materials written by stakeholders was whether the measurement, the “E” in WUE, should be effectiveness or efficiency. As commonly used, effectiveness refers to the amount of benefit obtained from water. Efficiency is the benefit, or effectiveness, per some unit of water.

The word effectiveness implies improvement. In other words, an action was effective if it made a change for the better. Therefore, Water Use Effectiveness would seem to measure whether a specific application of water is able to bring about ecosystem improvement. This word does not necessitate a measurement of the amount of water used. Because effectiveness does not require a measurement of the water used to obtain a benefit, it does not allow water planners to readily evaluate which application of water would be most beneficial given a specific amount of water. While effectiveness is preferred by some for its lack of parallelism to other sectors, not having a basis for comparison of competing uses (amount of water) weakens its use within the environmental sector as well.

The term efficiency has a more direct parallel with urban and agricultural WUE, which for some is positive, while for others is not. Some feel that efficiency implies a more rigorous measure that would allow for water in the environment to be evaluated in a similar manner as water in other sectors. Others are concerned that an efficiency measure requires a simplicity of analysis that is impossible or scientifically unsupportable, and might focus on micro-level indicators that do not accurately capture the complexities of ecosystem performance.

The issue of comparison is highly important to improving the way environmental water is used. If there were an infinite amount of water, there would be no need to compare the benefits of providing water among different uses. Unfortunately, as our readers are well aware, there will always be competing needs.
for water in California, both between sectors and within each sector. Given a limited amount of water, it is important to figure out which uses will provide the greatest environmental benefit. Without an effective measure of how much benefit is gained under each option for that amount of water, resources could be misallocated.

There may be times when an additional amount of water will greatly improve the ecosystem in one region, but only mildly improve another. It is even possible that too much water in a specific region could cause harm to that area and should be reallocated to an area in need. For this, understanding incremental improvements based on amounts of water will be necessary.

Therefore, we recommend that MEWUE be a measure of efficiency, not effectiveness. Efficiency includes a basis for comparison within environmental uses, which better describes the necessary concept. The definition of efficiency we are offering does not imply anything specific about how to measure benefits, nor does it suggest that they will be easily quantifiable. It does not necessarily suggest the existence of a single linear, numerical metric. Using the word efficiency is necessary to capture the idea that we want to evaluate benefits per unit of input, rather than simply the total benefit of a project independent of inputs.

The Case for Applying the MEWUE Concept
Many people are uncomfortable with the idea of having to measure environmental benefits, feeling that these benefits are inherently unquantifiable, or are so difficult to quantify that the exercise is best not pursued. It is obviously a difficult task to try to create a comprehensive calculation of the benefits the environment gains from water use. However, planners find themselves making these measurements implicitly all the time. Given competing water needs, there is no way to avoid them. Any time a decision is made to allocate water to one environmental project above another, the decision-maker is making a judgment that the first project creates greater benefit. Right now, those considerations can include political ease of decision, existing legal restrictions, and an understanding of ecosystem needs. MEWUE would be used to improve the information available for the decisions that are already being made. MEWUE would not create a new set of questions; rather, it would inform those questions that are already being asked.

It is hard to allay the fears that some have of incorrectly measuring environmental benefits. However, it is even more difficult to claim that decisions made based on implicit measures and beliefs are better for the environment than those made with broad involvement and based on some imperfect but explicit consideration of environmental benefits.

In addition, without a way to evaluate efficiency, it is difficult for water planners to learn from mistakes. It is necessary to implement a type of measure or process that would allow for a more systematic review of what types of water allocation are most beneficial for the environment. Even if the measure is imperfect, which any measure would certainly be, an effective process of implementing it will enable assessment of and improvement on its flaws. While the water planning community should take all possible steps to develop a correct and comprehensive measure, even an imperfect measure will provide a starting point for improving environmental water use. Without a measure, correct or incorrect decisions can be made, but little evaluation can follow.
The complex nature of the environment requires a comprehensive system to improve the efficiency of how water should be allocated to it. Multiple measurements will likely be necessary to understand environmental efficiency, and these measurements will likely require continual updating and revision. This should not be disheartening. Just as the Department of Water Resources dedicates an Office to understanding and improving urban and agricultural WUE, MEWUE will necessitate ongoing effort. We discuss the potential dimensions of this effort in Section 3.

**Summary**
MEWUE is a term intended to address the concerns of all parties discussing water use efficiency with respect to the environment. It is intended to be a starting point from which people can begin to assess the various ways to measure environmental benefits.

In this section, we have discussed the consensus concept MEWUE is designed to address (maximizing the benefit of given amounts of water dedicated to the environment by human decisions) and why it is important to consider that concept. We have not yet addressed the thorny question of how to implement a measure of the environmental benefits MEWUE would seek to maximize. Some potential approaches will be outlined in the remainder of this report. However, an understanding of how to improve efficiency will take time to evolve. Therefore, we feel that explaining the term and agreeing on its basic meaning are essential to maintaining the motivation to support the idea of improving MEWUE.

### 3.0 Potential Methods for Implementing MEWUE

#### 3.1 Technical Methods

##### 3.1.1 Ecological Indicators

**Description**
An ecological indicator is a “measurable feature or features that provides managerially and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality.”

Ecological indicators, as used in this report, refer to both biological indicators of water quality (bioassessment) and physical indicators of habitat suitability. There are variants of both assessment systems in use today in the United States and throughout the world. The most widespread use of biological indicators is in water quality monitoring. Currently, all 50 states, several tribes and territories, and several other countries have some level of bioassessment procedures in place for monitoring water quality, as well as investigating specific impairment or pollution events. Habitat quality assessment is also in wide use, although these protocols are less well-developed and standardized, probably due to the existence of fewer regulatory drivers.

The theory of bioassessment is based on the close relationship between the abundance and diversity of species (primarily benthic macroinvertebrates, algae, and fish) with known water quality tolerances and the quality of that water. Bioassessments are potentially very sensitive to a variety of aspects of water and habitat quality. Additional habitat quality indicators include assessments of channel dimensions, channel gradient, channel substrate size and type, habitat complexity and cover, riparian vegetation cover.

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14 Water Quality Indicators. State Water Resources Control Board. 12 April 2004
<http://www.swrcb.ca.gov/swamp/wqindicators.html>.
and structure, anthropogenic alterations, and channel-riparian interaction. These indicators may be used to assess the habitat suitability for species of concern, as well as overall ecological health.

**Case Study 2**

*Florida Uses Bioassessment to Target and Evaluate Restoration and Mitigation Projects*\(^{16}\)

The Florida State Department of Environmental Protection (DEP) uses bioassessment in monitoring of specific water bodies of concern, and has also used bioassessment in several cases to measure the effectiveness of specific management actions. For example, the DEP measured the conditions on Canoe Creek in northern Escambia County, before and after paving the upstream clay-bed Bratt Road. The 1997 assessment reported low ecological indicator index scores. The hypothesized cause of these low scores was sediment impacts from the unpaved road, which prompted mitigation measures. The 2002 assessment, after the road was paved, found an increase of 76%, 83%, and 59% in the three indices used, to between 160% and 210% of “threshold significance” levels.

Using ecological indicators allows DEP to target resources to greatest need, evaluate success of projects, and learn from experience.

**Case Study 3**

*Clean Water Act Water Quality Monitoring Increasingly Utilizing Ecological Indicators*

Water Quality Standards (WQS) under the Clean Water Act (CWA) consist of three elements: designated use, narrative and numeric criteria adopted to protect the use, and policies to prevent degradation. Ecological indicators are increasingly being used in monitoring to assess whether a waterbody meets its WQS, in reporting this status and in implementing mitigation and restoration measures.

Some states, such as Oregon, Ohio, Florida, Maryland, Kentucky, and Maine, have already constructed biological assessment and standards programs for streams and small rivers, and are managing their CWA programs at least partially through numeric or narrative ecological indicators. Most other states are developing programs and are at various levels of implementation.\(^{17}\) The U.S. Environmental Protection Agency (EPA) has recently instituted the Consolidated Assessment and Listing Methodology (CALM) to track, publicize, and facilitate states’ CWA bioassessment programs, a function exemplary of the benchmarking described in section 3.2.1.\(^{18}\)

The development of protocols and regulatory structure for the use of ecological indicators across the country provides multiple models and guides for their use in MEWUE assessment, both from a technical and a bureaucratic viewpoint. Adapting the model, not to mention the protocols and the data, of CWA bioassessment could yield significant cost efficiencies in ecological indicator development.

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\(^{16}\) *Bioassessment Ecossurveys of All Districts*. Florida Department of Environmental Protection. 15 April 2004 <http://tlhdwf2.dep.state.fl.us/eswizard/eco_results.asp>.


California Has Several Ecological Indicators Currently in Use

In California, ecological indicators of several different types are already used by DWR, the Department of Fish and Game, the State Water Resources Control Board, the Regional Water Quality Control Boards, the Department of Parks and Recreation, several municipalities including San Jose and San Diego, and several Native American tribes. Universities (UC Davis, Berkeley, and Los Angeles) and watershed citizen groups have also developed or used ecological indicator assessment. Two of the most developed methods are described in the following table.

Table 1

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description and Current Use</th>
<th>Potential Applicability to MEWUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>California Stream Bioassessment Procedure (CSBP)</td>
<td>The CSBP is a regional adaptation of the national Rapid Bioassessment Protocols outlined by EPA. The CSBP has been further refined by the Department of Fish and Game’s Aquatic Bioassessment Laboratory to be relevant to California’s ecoregions.</td>
<td>CSBP may be applicable in monitoring watershed health, assessing the efficacy and efficiency of specific restoration projects, or in targeting proposed projects.</td>
</tr>
<tr>
<td>California Monitoring and Assessment Protocol (CMAP)</td>
<td>CMAP is the California-specific evolution of EPA’s Environmental Monitoring and Assessment Protocol which assesses water quality. CMAP uses random, statistical selection of samples from a selection of reference and impacted sites to create a cost-effective monitoring system of trends.</td>
<td>CMAP may be applicable in monitoring the efficiency of water management alternatives across regions and over time.</td>
</tr>
</tbody>
</table>

Applicability to MEWUE

The use of indicators to measure the ecological benefits of managed environmental water use is feasible and appropriate. Myriad methods of ecological assessment that show significant scientific reliability have been and continue to be developed, including several in California. Indicators could be used to monitor ecological quality, to aid in deciding between projects, and to assess the effectiveness of completed projects and programs.

Selection of sufficient and appropriate indicators for assessing MEWUE is critical. A multimetric approach that captures the range of values for which it is important to manage is preferable to a simple measure such as single species populations. Ecological indicator selection should be accessible to broad stakeholder involvement, and not restricted to scientists and agency personnel.

Because bioassessments must be calibrated to reference “unimpaired” conditions, they are necessarily region-specific. The applicable scale of individual indices may range from the watershed to the

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20 California Monitoring and Assessment Program. Aquatic Bioassessment Laboratory, California Department of Fish and Game. 30 March 2004 <http://www.dfg.ca.gov/cabw/Field/cmap.html>.

ecoregion. Additional factors relevant to the selection of appropriate indicator protocols for MEWUE include the cost of collecting and analyzing samples and the level of precision desired by decision makers.

3.1.2 Instream Flow Requirements

Description

The term “instream flow requirements” refers to the quantity and schedule of water required to protect the structure and function of aquatic ecosystems at some specified level of ecological health. While methods for directly measuring ecological health are still evolving, there are currently several techniques available that can provide such measurements in comparison to a reference condition, such as natural flow. One such technique is the Instream Flow Incremental Methodology (IFIM), a tool used nationwide that is accepted by most resource managers as the best available method for determining the relationship between flows and aquatic habitats. This methodology aims to assess the ecological effect of incremental changes in stream flow through the following five steps:

- Problem Identification – Conduct physical analysis to define the affected physical location, and the aquatic resources of most concern. Perform legal-institutional analysis to identify interested parties and their objectives, and provide a better understanding of the impacts of the proposed project.
- Study Planning – Outline necessary data collection and require that all interested parties agree to a baseline hydrologic time series that will act as the reference condition.
- Study Implementation – Select sampling locations and collect data outlined in the Study Planning step, and use the results and predictive model (e.g. PHABSIM – physical habitat simulation) to estimate the relation between flow and total habitat.
- Alternatives Analysis – Compare alternative water uses against these instream flow requirements to determine the potential impacts of a proposed water project, and identify the habitat costs and benefits of the project.
- Problem Resolution – Reconvene interested parties to make a decision based on the results.

Collaboration among stakeholders is an important component of this process, as varying interests should agree on ecological health goals. Once instream flow requirements are set, environmental water allocation decisions can be guided by the relative ecological health improvements that result from application of a given amount of water. For example, if several areas are competing for water, planners could look at how well current allocations are meeting instream flow requirements in those areas. They could then make a decision based on which area(s) would achieve the greatest benefit relative to their targeted ecological health goals, thereby increasing the efficiency of managed environmental water.

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22 An ecoregion is an area of the country with similar geography, climate, and biology. There are considered to be 13 “Level III” ecoregions in California, according to EPA.


While uncertainty is present in this process, it can be reduced through careful study design, full inclusion of multiple viewpoints, and selection of an appropriate scale. Also, the accuracy of water project decisions can be evaluated and revised through post-project monitoring and analysis. In this way, adaptive management can reduce uncertainty and improve assessment and management of future projects.

**Case Study 4**

**Washington State’s Use of Instream Flows**

Washington State first introduced a systematic approach to instream flow protection in 1967. The legislation was updated with the Water Resources Act of 1971, which states the goals of water allocation in Washington as follows: “Allocation of water among potential uses and users shall be based generally on the securing of the maximum net benefits for the people of the state. Maximum net benefits shall constitute total benefits less costs including opportunities lost.” As stated in section 2.2 of this report, this concept of maximizing net benefits is consistent with views expressed by stakeholders in California.

The process for setting flows in Washington is a collaborative effort led by the Department of Ecology, the state’s principal environmental management agency. The department has authority to set flows only after going through public processes to ensure that issues are identified and considered. This gives local citizens, local government, state agencies, and tribes an avenue for involvement in establishing or amending instream flows. Flow recommendations must have unanimous support of all government members and tribes and a majority of non-government members. The technical process of setting flows utilizes IFIM and PHABSIM and takes multiple factors into account when setting flows, including fish, water quality, climate, dams, cultural values, and recreation, among other things. Using this information, the tools predict how the quantity of available fish habitat changes in response to incremental changes in flow.

The use of instream flow requirements in Washington has been influential in establishing management goals and maintaining sufficient levels of aquatic health. While controversy surrounded the initial setting of flows, the more collaborative approach that is now in place has acted to increase stakeholder satisfaction with the process. If California decided to pursue this approach, the state could benefit from Washington’s experiences, particularly regarding the collaborative process and the scientific techniques employed.

**Applicability to MEWUE**

This method provides an eco-centric approach to managed environmental water use efficiency. It attempts to determine the water needs of an ecosystem to protect fish and other environmental values, and to make management decisions based on this science. If implemented, a collaborative process like the one employed in Washington State allows stakeholders to provide input in setting or amending instream flow requirements and can thus increase stakeholder satisfaction. In addition, the process is quite amenable to adaptive management, as post-project assessment allows for a substantive evaluation of the accuracy of predicted instream flow requirements, which can subsequently be updated. This approach can also reduce uncertainty, as future modeling can be revised based on these post-project analyses. Technical feasibility is another strength of this technique, as widely accepted technology (IFIM) is

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27 We discuss the importance of collaboration in more detail in Section 3.2.2.
available to develop instream flow requirements based on a baseline hydrologic time series. The technical viability of this method is also supported by successful implementations in other countries (such as South Africa)\textsuperscript{28} and states, including Washington.

This technique improves efficiency of environmental water use by ensuring that management decisions are made in the context of approaching an accepted “goal” condition. The extent to which managed flows achieve this goal is a measure, albeit rough and unquantified, of benefits. Stakeholders interested in achieving a single metric of efficiency may not be satisfied. Furthermore, several factors prohibit this method from guaranteeing a single, best solution. Ecological complexity makes it impossible to fully assess and model the health of a given ecosystem, which leads to imperfection and uncertainty in the data and models. In addition, rational people may disagree, even on a science-based process, and so the collaborative process is not guaranteed to produce consensus. Still, the process would strengthen the scientific basis for environmental water allocation decisions.

3.1.3 Economic Valuation

Description

Economic valuation of ecological services and environmental quality is a rapidly developing field and is increasingly being used in natural resource management. Theoretically, accurate economic valuation of the benefits of alternative environmental water uses could be used to calculate the relative efficiency of these actions.

The purpose of any economic valuation is to estimate the value that consumers place on goods and services. When those goods and services are traded in a well-functioning market, their value can be assumed to equal their price. When, like environmental values, these goods and services are not traded in a market, their value must be deduced through “non-market valuation” techniques. There are a variety of such techniques that have been developed to estimate the public’s value for environmental goods and services.\textsuperscript{29} Because of the large number of people affected, the sum of the value citizens place on environmental amenities can be quite large.

Economic valuation is already used to some extent by government agencies in cost-benefit analysis of water management alternatives, including water storage development, conservation measures, and specific restoration projects. It is also used in environmental damage assessment. Most non-market economic valuation is being conducted in the academic context.


\textsuperscript{29} See Appendix C for more details.
Case Study 5
South Platte River Conservation and Restoration Valuation Study

Loomis et al. studied local residents’ value for restoring certain ecosystem services along a 45-mile stretch of the ecologically important yet highly impacted South Platte River in Northern Colorado. One hundred residents participated in an in-depth valuation survey that elicited yes-or-no reactions to randomly-generated “proposed” water fees, which were analyzed to arrive at respondents’ average “willingness to pay” regarding purchasing increased ecosystem services.

The study involved extensive respondent education in current resources and land use, proposed restoration and mitigation activities, and expected environmental benefits. These benefits would be achieved through specific management actions including purchasing a ten-mile-wide conservation easement along 45 miles of the river, creating buffer strips where cropland and cattle grazing would be eliminated and native vegetation would be planted, and buying water rights to increase stream flows by 50% to 70%. The ecosystem services residents were asked to value included dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation.

A mean annual household willingness to pay of $252 was estimated for the increase in ecosystem services on the 45-mile stretch of the river. This value, summed across the area’s population, establishes an estimated value to the public of performing the actions of at least $19 million, compared to an estimated cost of the proposed actions of $13.5 million. Although no tax or charge resulted from the study, this estimated value has supported the conservation work of the Fish and Wildlife Service and Centennial Land Trust.

Applicability to MEWUE
Economic valuation may be useful as a component in estimation and quantification of environmental benefits to aid in MEWUE assessment. A study such as the South Platte study could be conducted before a project or management decision to gauge the public’s value of the environmental benefits, or after a change to determine the value achieved. With additional development, such a study could be used to inform decision-making on proposed projects, to assess relative efficiency of alternative programs or projects, and to evaluate success of existing programs.

Economic valuation would probably be most useful as a measurement of long-term, regional-scale, aggregate benefits of environmental water allocations. For instance, an economic valuation of CALFED ecosystem restoration activities is a feasible use of this technique. Economic valuation may also be most useful as a component of ex ante assessment of restoration alternatives. Depending on the quality and comprehensiveness of the analysis, comparative valuation of ecosystem benefits between projects may be an important contribution to decision making.

However, economic valuation cannot stand as a sole quantitative assessment of environmental benefits. Valuation techniques still only measure a portion of value that may be attributed to environmental

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To the extent that important environmental values are missing, economic valuation may not be an appropriate tool for seeking to maximize environmental benefit.

Given the range of services to be valued and the immaturity of the methods, economic valuation continues to be highly controversial. It is often questioned by those that find the methods and values unreliable and by those that feel it is immoral or impossible to value the natural world. For these reasons, economic valuation continues to have limited support in some sectors, including public opinion.

### 3.2 Institutional Methods

#### 3.2.1 Benchmarking and Best Management Practices

**Description - Benchmarking**

Benchmarking is the process of monitoring the performance of management practices and restoration projects and identifying the most efficient among them for possible adaptation and implementation elsewhere. Benchmarking establishes performance standards that other managers or projects seek to emulate. The process of benchmarking moves an industry overall toward greater efficiency over time.

Benchmarking has two parts: the harvesting of benchmarks from existing projects and the application of these standards to future projects. In the harvesting step, assessing the success of projects and identifying best practices requires some process of systematic assessment and some measure of success. Benchmarks may be tolerant of some uncertainty in the measurement of benefits and could be implemented with relatively loose quantitative or even qualitative measures. Benchmarks might be based on ecological indicators, or on more subjective criteria, such as the success of projects in meeting pre-project objectives.

With a centralized agency monitoring the success of projects or programs across agencies and districts, benchmarks can be identified and publicized, allowing future projects or management decisions to adapt and apply successful models. Benchmarking is also accomplished by project sponsors being responsible for post-project auditing of water management regimes and restoration projects and publicizing exceptional results. This serves the dual purpose of harvesting benchmarks of success and providing some degree of accountability for success.

An ongoing benchmarking process would institutionalize adaptive planning. Projects would be explicitly studied for successful and unsuccessful components, which would then be incorporated or avoided, respectively, in future projects. Benchmarking can be conducted on a comprehensive basis across programs, as an added audit requirement on individual projects, or both. A benchmark program may be implemented by individual managers, or it may be undertaken by a centralized agency.

Benchmarking the efforts of California’s water managers to measure and improve MEWUE would increase the rate of diffusion, adoption, and innovation of successful practices and over time increase efficiency. Benchmarking may also lead to the identification of Best Management Practices.

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32 For instance, valuation techniques will only capture anthropogenic value. That is, they do not express any intrinsic value of nature, but rather reflect the values humans ascribe to nature.
Description - Best Management Practices (BMPs)

Best Management Practices are practices or policies that have consistently provided examples of successful performance and have been demonstrated to be cost-effective when implemented on a wide basis. BMPs reduce information costs to individual water managers and are by design robust in the face of uncertainty. BMPs represent “no regrets” actions, actions that have a high likelihood of being successful, regardless of uncertainties as to the magnitude of the effect. BMPs provide off-the-shelf solutions to improving efficiency, and so reduce information costs to individual water managers.

BMPs are well established in the agricultural and urban sectors. Effective Water Management Practices (EWMPs) in the agricultural sector have helped drive significant gains in efficiencies in this sector. Similarly, urban water suppliers have adopted BMPs requiring the implementation of 14 specific management programs or practices, as discussed in the case study below.

Case Study 6

California Urban Water Conservation Council Best Management Practices

In 1991, more than 100 urban water suppliers committed to implementing long-term conservation measures called Best Management Practices, or BMPs, by signing the Memorandum of Understanding Regarding Urban Water Conservation (MOU). Today, more than 310 urban water suppliers, public advocacy organizations, and other interested parties have signed the MOU, forming a coalition known as the California Urban Water Conservation Council (CUWCC). These signatories have voluntarily committed to implementing 14 BMPs, including surveys of users’ baseline consumption and practices, audits of waste and leaks, implementation of specific conservation technologies, and conservation pricing.

The development of urban WUE BMPs allows water managers some certainty in the cost-effectiveness and benefits of proposed actions. Furthermore, the CUWCC process demonstrates a process for developing statewide, stakeholder-based agreement on BMPs.

Applicability to MEWUE

The evaluation of managed environmental water use efficiency is of little value without a process for deriving lessons from the process to be applied to future projects and management regimes. BMPs in a MEWUE context would be restoration projects, technologies, or management programs that have proven to be cost-effective in increasing efficiency of managed environmental water use. Examples of possible MEWUE BMPs include fish screens on water supply intake facilities and restoration techniques developed for the California Salmonid Stream Habitat Restoration Manual.

BMPs have potential to be successful in cost-effectively increasing WUE for managed environmental water, just as they have done for agricultural or urban WUE. MEWUE BMPs must be carefully developed to ensure effectiveness and must be adaptable over time.


3.2.2 Improved Water Management and Collaboration

Description
Several stakeholders mentioned that a lack of effective communication mechanisms and regulatory inflexibility often stand in the way of effective decision-making. Many argue that this lack of communication has led to inefficiencies in water management. For example, several stakeholders suggest that this lack of communication led to the inefficient use of water in the 2003 Folsom Dam release that we reference as a case study in Section 2.1. As we mentioned, that process did not involve a discussion of the tradeoffs between different potential actions. Making this decision within a framework of collaborative decision-making may have helped mitigate the negative results.

This section suggests the need for a new or enhanced mechanism for communication and decision-making that more effectively addresses ecosystem needs. The goal would be to create a collaborative process that would allow for a more flexible response to situations like the Folsom Dam release. Such an approach requires a commitment to understanding the interrelation of various goals within water planning.

Incorporating this approach would involve choosing from a range of options – from increased reliance on existing collaborative communication structures to replication of those systems that work well in some areas into other water planning situations. One possible outcome could take the form of a more formal communications structure, such as the case study discussed below. Another option might incorporate collaboration into decision-making processes that currently occur at various water planning levels (districts, etc.). The actual form that collaboration would take will vary across settings and requires an evaluation of current planning processes to determine where gaps in communication exist. The most important aspect of this approach is establishing a framework within which multiple stakeholders with diverse interests can identify areas of conflict and commonality.

Case Study 7
Calfed Operations Group (Calfed Ops)
The agreement to establish Calfed in 1994 “ended decades of infighting and regulatory uncertainty.”35 Multiple agencies with a stake in Bay-Delta water planning created Calfed to address a lack of agency communication and deadlocked interests. Calfed, a collaborative resource program, was created with the mission to “develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta.”36 Calfed makes real-time management decisions through an interagency group known as Calfed Ops. The fundamental notion of Calfed Ops is that agencies can best meet their individual responsibilities by sharing information.

Calfed Ops functions as a resource for all agencies involved in water planning in the Bay-Delta.37 The idea behind the Ops group was that “information on fisheries, and water quality and flows, could be evaluated quickly using the distributed intelligence of the diverse agency and stakeholder members.”38

37 Participating agencies include DWR, Bureau of Reclamation, NMFS, USF&WS, EPA, DF&G and SWRCB.
CALFED Ops works to identify the interrelation of the goals of its subcommittee members\(^{39}\) to detect potential conflicts and identify actions that will promote the goals of multiple subcommittees.\(^{40}\) This process helps project planners determine the potential impacts of the activities they are pursuing, and CALFED Ops creates the communication and coordination mechanism within which consensus-based decisions can be made. CALFED Ops holds monthly meetings to make decisions and discuss potential changes and strategies. Decisions can involve changes in export rates, barrier operations, and reservoir releases. Ops group deliberations are conducted in consultation with water user, environmental, and fishery representatives.

On a host of outcomes by which to evaluate collaborative decision making, CALFED Ops scores highly. These measures include increased social and political capital, agreed-on information and shared understanding, end to stalemate, high quality agreements, innovation, and institutions and practices that involve flexibility.\(^{41}\) For example, the Ops group played a critical role in November and December of 1999, when “dry conditions, in combination with record high tides and the onset of a salmon out-migration produced a very complex and difficult water management situation.”\(^{42}\) CALFED Ops work groups held almost daily consultations during the five weeks these conditions prevailed, and “decision making was quick and effective, occurred at the lowest levels possible and the process provided a much more nuanced response than a single bureaucratic agency could provide.”\(^{43}\)

What stands out about how decisions were made in November and December of 1999 is that “unlike the way decisions were made prior to CALFED, the regulatory agencies were all involved in the decision-making, along with the resource managers and stakeholders.”\(^{44}\) “A particularly extraordinary aspect of this innovation [CALFED Ops] was that stakeholders representing typically opposing viewpoints were able to come to agreement.”\(^{45}\) In this case, resource managers faced different regulatory requirements that conflicted with each other. In the end, despite the fact that not all stakeholders were pleased with all outcomes, they all believed in the process of reaching decisions together.

**Applicability to MEWUE**

This approach to MEWUE would aim to improve communication by introducing a collaborative decision-making approach that explicitly aims to reduce conflicts and to support multiple goals of water planning interests. Water planners are likely to improve the efficiency of environmental water use within an improved decision-making structure. Currently, conflicts between various regulatory requirements and lack of a comprehensive water management structure for day-to-day communication and management may create inefficiency in the application of environmental water. Once a collaborative process is underway, it could potentially serve as a way to identify regulations that perhaps need changing or system-wide review among federal, state, and local water managers.

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39 Subcommittees include: Delta Levee habitat, drinking water, ecosystem restoration, environmental justice, water use efficiency, watershed, water supply and working landscapes.


41 Connick & Innes (2001)

42 Connick & Innes (2001)

43 Connick & Innes (2001)

44 Connick & Innes (2001)

45 Connick & Innes (2001)
This approach does not establish a mechanism with which to measure these improvements. Still, guidelines do exist for developing performance measurements using criteria such as an increase in high quality agreements, an end to stalemate, etc.\footnote{Connick & Innes (2001)}

If instituted in a more formal manner, this method may take some time to yield results. The development of CALFED was a multi-year effort that required commitment from many stakeholders to work through the process. However, given that there is an existing framework from which to model future communication structures, it is possible that planners would see preliminary results reasonably quickly.

Implementing this method could involve some technical or legal difficulties to the extent that it suggests the need for changes in institutional structure or behavior or changes in regulation. However, the main thrust of this suggested approach is increasing communication and developing consensus-based decisions around current regulatory requirements, which in and of itself is not likely to involve technical or legal difficulty. Should future legislative action be determined necessary, a framework will exist within which to advocate for proposed legal changes. This method does not directly encourage adaptive management, but enhanced communication could potentially create a more flexible, adaptive decision-making context.

### 4.0 Conclusions and Recommendations

#### Coming To Terms with MEWUE

The scarcity of water in California necessitates the efficient use of any given quantity. Despite perceived disagreement about WUE for the environment, there is consensus among the stakeholders with whom we spoke that environmental water management should strive to achieve the greatest amount of benefit possible from the water made available. This key concept can provide the foundation for developing and implementing MEWUE.

Terminology being as important as it is, a large part of our task has been to develop a term to accurately describe what the concept encompasses and what it doesn’t. We propose the term Managed Environmental Water Use Efficiency – MEWUE – to satisfy these concerns. We intend MEWUE to address the objections stakeholders voiced with other suggested terms, and to define our scope of inquiry as uses of water dedicated to the environment through human management.

Appropriately implemented, MEWUE would be a systematic method of measuring and improving the benefits of specific environmental water uses. It would also allow evaluation of the relative efficiency of one use of managed environmental water over another. MEWUE would replace implicit assumptions about the efficiency of managed environmental water with explicit assessment. MEWUE can also provide a mechanism for improving management over time and increasing accountability for environmental water use decisions.

Many tools that could be used to measure or improve MEWUE are currently in place or are being developed. The condition of California’s aquatic environments (including water quality, habitat suitability, etc.) is monitored under a variety of programs and with various techniques. Also, individual restoration projects or ecological flow regimes are often evaluated for effectiveness in meeting some set
of goals. Successful management practices and standard restoration techniques are identified and publicized. Regulatory changes and interagency management and communication initiatives are occasionally initiated. To a large extent, then, the recommendation of this report is to recognize and embrace these components as ingredients in a system to evaluate and maximize the efficiency of water management for environmental benefits, under the common rubric of MEWUE.

**A Comprehensive and Collaborative Approach to Defining and Implementing MEWUE**

The identification of the environmental benefits that are gained per unit of water is a difficult and controversial task, given the complexity of any ecological system. Precisely quantifying these benefits is beyond the reach of current science and economics. In the absence of a single measure, whatever method is used to determine these benefits should be as comprehensive as possible to accommodate the range of values associated with healthy ecosystems. Single species metrics will generally not be sufficient. However, a modification of the variety of ecological assessment techniques and metrics presently available could be constructed to act as a standardized measure of ecological benefits, at least within ecoregions.

**Potential Approaches to Implementing MEWUE**

- Employ quantitative ecological monitoring and evaluation programs to create baseline data, monitor trends and aggregate performance, and perform targeted efficiency assessment of individual projects.
- Perform instream flow requirements analysis to establish habitat goals for California’s aquatic habitats.
- Further develop the role of non-market economic valuation in cost-benefit analysis of alternative projects and management regimes.
- Establish a benchmarking process for environmental water management.
- Create a process for establishing Best Management Practices for environmental water uses.
- Create an interagency collaborative working group for environmental water management decision-making, program and regulatory harmonization, and coordination of research.

Furthermore, there are ongoing efforts to improve environmental water use and ecosystem restoration projects, but they have not been recognized as measures that increase the efficiency of managed environmental water uses. We recommend populating MEWUE with a variety of efficiency-promoting practices. These practices include instream flow assessments, project auditing, benchmarking, and best management practices.

Given the variety of viable approaches and the diversity of stakeholder perspectives, we recommend an ongoing collaborative process (similar to those conducted by CALFED) to define and implement MEWUE. We view such an approach as important in ensuring a comprehensive and mutually acceptable approach to solving the difficult benefits evaluation issue. A collaborative approach would also facilitate improvements in interagency communication and decision-making structures.

We do not provide in this report a single answer or approach for defining and implementing MEWUE. Rather, we have demonstrated the importance of the concept and introduced the idea that many practices championed by various stakeholders can play a part in MEWUE. We hope that this report provides a
term and concept around which a collaborative discussion can be structured about how best to implement this concept.

**Summary of Key Points**

- This report provides a term and concept around which a collaborative process can be structured.
- Despite perceived disagreement about WUE for the environment, there is consensus that environmental water management should strive to achieve the greatest amount of benefit possible from the water made available.
- MEWUE – Managed Environmental Water Use Efficiency – is a suitable term to express this goal.
- Multiple current efforts and practices are related to MEWUE, and potentially can be incorporated into its implementation.
- Although precise quantification of environmental benefits is exceedingly complex, ecological indicators can provide useful measurements of ecosystem health and instream flow requirements can provide management goals. Benchmarking and Best Management Practices are techniques that could operationalize MEWUE.
- Given the variety of viable approaches and the diversity of stakeholders, an ongoing collaborative process (similar to those conducted by CALFED) can help define and implement MEWUE.
### APPENDIX A: State Water Plan Update 2003 Public Advisory

#### Committee Members

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization/Agency</th>
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<tbody>
<tr>
<td>Margit Aramburu</td>
<td>Delta Protection Commission</td>
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<tr>
<td>Mary Bannister</td>
<td>Pajaro Valley Water Management Agency</td>
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<tr>
<td>Kirk Brewer</td>
<td>California Water Association</td>
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<td>Merita Callaway</td>
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<tr>
<td>Scott Cantrell</td>
<td>California Department of Fish and Game, Sacramento</td>
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<tr>
<td>Grace Chan</td>
<td>Metropolitan Water District of Southern California, Los Angeles</td>
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<td>Jim Chatigny</td>
<td>Mountain Counties Water Resources Association</td>
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<td>Marci Coglianese</td>
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<td>Bill Cunningham</td>
<td>U.S. Natural Resources Conservation Service, Davis</td>
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<td>Grant Davis</td>
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<td>Martha Davis</td>
<td>Inland Empire Utilities Agency, Rancho Cucamonga</td>
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<td>Mary Ann Dickinson</td>
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<td>Nick Di Croce</td>
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<td>Fran Garland</td>
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<td>Betsy Reifsnider</td>
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<td>Robert Wilkinson</td>
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<td>Executive Partnership for Environmental Resources Training, Inc.</td>
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<tr>
<td>Carolyn Yale</td>
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<td>Tom Zuckerman</td>
<td>Central Delta Water Agency</td>
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Considering Water Use Efficiency...
APPENDIX B: Interview Questions

Background
What do you work on? How is this concept relevant to your interests and those of your organization?

The WUE concept
When you hear the term “water use efficiency,” what is your reaction? What do you understand the term to mean generally?

To you, what should Ecosystem Restoration Water Use Efficiency mean? What is the concept fundamentally about? What should it measure (regardless of whether it can or not)?

What, specifically, are you most interested in changing through this concept? If this concept will not change whatever you feel is the critical issue, what would?

If conducted correctly, what good will come out of the process of defining and implementing this concept?

What, if anything, concerns you about the process of defining and implementing WUE? Are there critical interests that you fear may be compromised by this endeavor? What, specifically, are they?

Existing Reference Points
Do you have examples of water use for ecosystem restoration that is inefficient or could be more efficient?

Do you see any significant regulatory barriers to WUE? What, specifically, are they? Are there new regulatory approaches that could facilitate the concept?

How do you feel that your concept of ecosystem restoration efficiency might be measured? Are you aware of any existing literature that you find particularly applicable/compelling? What ecological indicator methods are you aware of that might be specifically relevant to this project?

How do you currently measure/assess the merit of restoration projects at this time (assuming you think about such things)?

Are you aware of approaches to this problem that you consider best management practices?

Have you done work on this concept before? Are you aware of others who have, or others we should talk to for whatever reason? Who? How about the parallel concept for other uses (agricultural/urban water use)?

47 These questions served as the basis for our conversations with stakeholders and often we did not ask them verbatim. Rather, the questions served to guide these interviews and ensured that major points would be addressed during the course of our conversations.

48 At the time we prepared this questionnaire, Ecosystem Restoration WUE was the term in use.
Current Project

What do you feel would be the most potentially beneficial outcomes of the GSPP team’s work on this issue? What specific outputs would you find valuable? How can we be helpful to you and to the problem?

How do you feel about the interaction of different actors and stakeholders who participate in the water planning process? How do you feel this process could be improved?
APPENDIX C: Economic Valuation Methods

Market Price Method
Estimates economic values for ecosystem products or services that are bought and sold in commercial markets.

Productivity Method
Estimates economic values for ecosystem products or services that contribute to the production of commercially marketed goods.

Hedonic Pricing Method
Estimates economic values for ecosystem or environmental services that directly affect market prices of some other good. Most commonly applied to variations in housing prices that reflect the value of local environmental attributes.

Travel Cost Method
Estimates economic values associated with ecosystems or sites that are used for recreation. Assumes that the value of a site is reflected in how much people are willing to pay to travel to visit the site.

Damage Cost Avoided, Replacement Cost, and Substitute Cost Methods
Estimates economic values based on costs of avoided damages resulting from lost ecosystem services, costs of replacing ecosystem services, or costs of providing substitute services. Most famous example is New York City’s estimation of the value of watershed protection and enhancement, based on avoided costs of drinking water treatment.

Contingent Valuation Method
Estimates economic values for virtually any ecosystem or environmental service. The most widely used method for estimating non-use, or “passive use” values. Asks people to directly state their willingness to pay for specific environmental services, based on a hypothetical scenario.

Contingent Choice Method
Estimates economic values for virtually any ecosystem or environmental service, based on asking people to make tradeoffs among sets of ecosystem or environmental services or characteristics. Does not directly ask for willingness to pay—this is inferred from tradeoffs that include cost as an attribute.

Benefit Transfer Method
Estimates economic values by transferring existing benefit estimates from studies already completed for another location or issue.

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By Environmental Defense
To: Kamyar Guivetchi, DWR, Michael Perrone, DWR, Jennifer Koiford, DWR

CC: B160 Advisory Committee Members

From: Ann Hayden

Date: October 29, 2004

Subject: Recommendations regarding scenarios and application of environmental water “demands” in the State Water Plan Update.

Thank you for the opportunity to provide comments on the substance, direction, and role of environmental water use, including unmet objectives, for the State Water Plan update. We appreciated the opportunity to discuss this issue with DWR staff last August 17, and would now like to provide comments on how the Plan can more clearly address environmental water use. We recognize and appreciate the progress made in addressing unmet environmental objectives in the Plan, and we hope the material can be more clearly presented and incorporated into the various scenarios. In this memo, we provide recommendations for how this material can best be incorporated in the current structure of the Plan.

Past State Water Plans have not adequately addressed unmet environmental objectives. Last year Environmental Defense, at DWR’s request, analyzed certain locations where flow and water delivery objectives for environmental uses were identified as unmet. Our findings are outlined in the attached memo, “Quantification of Unmet Environmental Objectives in State Water Plan 2003 using actual flow data for 1998, 2000, and 2001.” The memo clearly states that the analysis was conducted for a limited set of environmental objectives, and recommends that DWR conduct a more comprehensive analysis of environmental objectives throughout California. The results from our analysis are not to be interpreted as the outcome of a comprehensive assessment. Therefore, the use of our estimates in the Plan must be accompanied with a clear statement of their limited scope.

It is particularly important to acknowledge the limited nature of our analysis since it appears our estimates will be used to represent environmental demand in the “Quantified Narrative Scenarios” for Chapter 3. In addition, it is necessary to clarify that environmental objectives (or “Environmental Demand”) and environmental uses are two different things. To this end, the “Initial Conditions” should include both current
environmental uses and current environmental objectives, and therefore indicate current unmet objectives as well. It should be clearly stated in the Plan that a more comprehensive analysis of objectives would likely result in a higher level of environmental demand. Likewise, it should be emphasized that in the future these environmental objectives may change in one direction or another, but it might be too speculative to suggest the direction of any such changes at this time.

In the draft text we reviewed, the scenarios are not clearly defined. If the Plan is to be a useful document, it is imperative that readers understand what each scenario represents.

Based on our understanding of what the scenarios represent, we provide the following recommendations for both better describing the scenarios and characterizing environmental demands:

- The “Current Trends” scenario should represent a future if the present trend continues. Under this scenario, environmental objectives (on a limited set of streams and wetlands) would not change, but only one half (50%) of the environmental objectives would be achieved.
- The “Resource Sustainability” scenario should represent a future with a greater level of environmental protection. Under this scenario, objectives (on a limited set of streams and wetlands) would not change and 100 percent of the environmental objectives would be achieved.
- The “Resource Intensive” scenario should represent a future with less water available to the environment. Under this scenario, neither the current environmental objectives (on a limited set of streams and wetlands) nor the degree to which they are met would change.

Adopting these recommendations and incorporating the suggested clarifications will, in our opinion, result in a much more transparent, accurate, and useful State Water Plan. We look forward to continuing to work with your staff to help improve the Plan.

Sincerely,

Ann Hayden
Water Resource Analyst
As requested, we are re-submitting the following summary of our preliminary analysis of existing unmet environmental flow objectives. We greatly appreciate the feedback we recently received from DWR staff and have incorporated suggestions accordingly, which will be discussed in greater detail below. Due to time constraints, this analysis was conducted on only a partial list of objectives; we strongly encourage DWR to conduct a more rigorous analysis of unmet environmental objectives statewide.

Statewide, numerous environmental flow objectives exist that continue to go unmet, such as federal and State legal mandates to double salmon populations. The purpose of our analysis is to identify and quantify these gaps. Whether these objectives are adequately met under these alternative scenarios in the State Water Plan update is a matter for staff and AC consideration, but we hope that providing a quantified summary of such objectives will shed some light on what is actually occurring.

At the core of many of these environmental flow objectives is the goal of re-creating the natural hydrograph in systems impaired by water storage projects. By establishing appropriate flows, riverine ecosystems processes can be maintained, such as channel and riparian vegetation corridor maintenance, and ultimately the maintenance of aquatic species populations can occur.

The primary difference between this updated analysis and our previous analysis is the use of actual flow data for 1998, 2000, and 2001 representing a wet, normal and dry year, respectively. This approach is in contrast to our previous application of CALSIM, a model based on historical flow. Since there are many unresolved issues at to how CALSIM should be used in the State Water Plan update, we decided for the sake of consistency we would use actual flow data. It should be noted, however, that there are some limitations or possible inaccuracies when using actual flows. For instance, higher B2 flows were in place in 1999 before the new policy came out which significantly
changed how the water was accounted for; therefore, some of the unmet flow needs may appear to be lower using actual flow data that they would be today.

As a preliminary analysis, we chose the following objectives to be quantified:

- Trinity River flows consistent with Trinity River Mainstem Restoration Plan ROD (fall 2000).
- Additional water required meeting the flow objectives in the “Final Restoration Plan for the Anadromous Fish Restoration Program” (2001).
- A level of protection in the Bay-Delta that is equivalent to that specified by CALFED ROD, and required for long-term ESA assurances. This includes a viable Environmental Water Account, the Interior decision for CVPIA B2 water that allows crediting within metrics (i.e. pre-offset-reset ruling) and a fully functional Tier 3.
- San Joaquin flows needed to comply with the federal court order to restore the salmon fishery below Friant Dam.
- All Level 4 Refuge Supplies.
- The Ecosystem Restoration Program purchases identified in the CALFED ROD for Stage One implementation to be used to meet the flow objectives outlined in the CALFED Final EIR/EIS (July 2000).
- San Joaquin River flows at Vernalis consistent with levels specified in the 1995 Water Quality Control Plan.

A preliminary assessment of quantified unmet environmental objectives for these locations is provided in a summary table and discussion below. It’s worth mentioning that there is considerable variability in the extent to which there is conflict between meeting these objectives and meeting water delivery objectives for the urban and agricultural sectors.

Summary

Our analysis suggests the following quantities for the selected unmet objectives. Note that in some cases, there would be an effect on consumptive use and in other cases no effect. For example, American River flows might be recaptured in the Delta, while Trinity River flows would not be recaptured.

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<th>American (Nimbus)</th>
<th>Stanislaus (Goodwin)</th>
<th>ERP #1 Flow Obj.</th>
<th>ERP #2 Flow Obj.</th>
<th>ERP #4 Freeport (Dayflow)</th>
<th>Trinity (Lewiston)</th>
<th>SJR at Vernalis (Dayflow)</th>
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<td>76</td>
<td>242</td>
<td>99</td>
<td>62</td>
<td>313</td>
<td>125</td>
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</table>
American River

Existing American River flows were identified on the California Date Exchange Center (CDEC) database website as the flows below Nimbus reservoir. Objectives for the American River are outlined in the Anadromous Fish Restoration Program. This analysis determined an annual average deficiency of environmental flows of 25 TAF in 1998, 55 TAF in 2000, and 81 TAF in 2001.

Stanislaus River

Existing Stanislaus River flows were identified on the CDEC database as the flows below Goodwin dam. Objectives for the Stanislaus River are outlined in the AFRP. This analysis determined an annual average deficiency of environmental flows of 7 TAF in 1998, 34 TAF in 2000, and 0 TAF in 2001.

Ecosystem Restoration Program

The CALFED Ecosystem Restoration Program focuses on the connection between meeting the flow needs on the Sacramento, Feather, Yuba, American, Mokelumne, Tuolumne, and Merced Rivers and the freshwater inflow needs in the Delta. The ERP includes three quantifiable flow objectives for each year type, including Target 1: March outflow, Target 2: late April to early May outflow, and Target 4: May flows on the Sacramento River. For the purposes of this analysis, for Target 2, we assumed the ERP pulse flow would occur in the wetter period, which typically was in April. For all the targets, the target flows had to occur for ten days and we assumed flat flows across the month. Existing flows for each of these targets are identified using Interagency Estuary Project (IEP) Dayflow database. This analysis determined the following average deficiency of environmental flows: ERP #1: 0 TAF in 1998, 0 TAF in 2000, and 0 TAF for 2001. ERP #2: 0 TAF in 1998, 65 TAF in 2000, and 76 TAF in 2001. ERP #4: 0 TAF in 1998, 0 TAF in 2000, and 242 TAF in 2001.

Trinity River

Existing Trinity River flows were identified on the CDEC database as the flows below Lewiston Reservoir. Daily flow objectives for the Trinity River are from the Trinity River ROD. This analysis determined an average deficiency of environmental flows of 168 TAF in 1998, 344 TAF in 2000, and 99 TAF in 2001.

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Footnotes:
1 Final Program for the Anadromous Fish Restoration Program, 2001
3 http://cdec.water.ca.gov/
San Joaquin River at Vernalis

Existing flows for the San Joaquin at Vernalis were identified using Dayflow data. Flow objectives at Vernalis are identified in the 1995 Water Quality Control Plan and occur from April 15 - May 15. This analysis determined an average deficiency of 97 TAF in 1998, 96 TAF in 2000, and 62 TAF in 2001.

San Joaquin River below Friant

San Joaquin River flow objectives are based on a URS Report, completed as part of the settlement process between NRDC and the Friant Water Users Authority. Currently, 117 TAF flows are annually released down the San Joaquin River to satisfy downstream prior-right riparian water user and contract objectives.

The environmental flow objectives for the San Joaquin River are provided in the water quality study and determined an annual average deficiency of 0 TAF in 1998, 268 TAF in 2000, and 313 TAF in 2001.

Level 4 Refuges

As prescribed in the CVPIA, Level 4 Refuge Water is the water needed in addition to current average annual water deliveries (Level 2 Refuge Water) to 19 Sacramento and San Joaquin refuges. Incremental Level 4 water is based on 10% increments of water to be delivered to the refuges until year 10 (2002) when it was expected the full amount would be attained. To date, this amount has not been largely due to funding limitations and the growing cost of water (e.g.: average cost of water has increased from $50-60/af in 1995 to $125-$150/af in just eight years). Moreover, necessary construction of refuge conveyance systems has not occurred at a number of refuges, further limiting the supply of water to the refuges. The annual unmet environmental water needs at Level 4 Refuges was 125 TAF for 1998, 2000, and 2001.

EWA and B2

The B2 Account and EWA are environmental obligations prescribed in the CVPIA and CALFED ROD, respectively, to provide benefits to fisheries and aquatic habitat in the Central Valley and Bay-Delta. In terms of B2, Interior’s most recent 2003 policy for managing B2 supplies has significantly diminished the amount of water available for protection and restoration. As for the EWA, while protective operations have had some positive effects on aquatic habitat and the health of the Delta’s fisheries, gaps in this

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account still exist. The size and operation of the EWA is currently being revised in light of changes to state and federal water operations.

While the above preliminary analysis provides much needed information on unmet needs, there are still many other environmental water objectives that need to be quantified. A truly comprehensive analysis would include environmental water legal mandates that occur statewide, extending from the Klamath River in the north to the Salton Sea in the south. Even in the Bay-Delta, more quantification is necessary. Unfortunately, while data exists to analyze some of these objectives, there are significant gaps in data collection throughout the state—a fact that requires serious attention and action from relevant agencies. We strongly encourage DWR to fill these data gaps where possible and complete a total assessment of unmet environmental objectives throughout the state.
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Environmental Justice in California Government

By Governor’s Office of Planning and Research
ENVIRONMENTAL JUSTICE IN CALIFORNIA STATE GOVERNMENT

October 2003

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ENVIRONMENTAL JUSTICE IN CALIFORNIA STATE GOVERNMENT

PREFACE

In California, we have spent over a century and billions of dollars to preserve and protect the environment for current and future generations. The EJ movement asks us to put real people in that environment, particularly the most vulnerable populations such as ethnic minorities, low-income persons, the young and the elderly. In a nutshell, EJ can be said to be the vision and process of creating socially just, sustainable human and ecological systems, where all participate fully in decisions affecting their lives.

The Governor’s Office of Planning & Research (OPR) assists the Governor and the Administration in land use planning, research, liaison with local government, small business advocacy, rural policy, and various interagency taskforces. 1999 legislation defined EJ in California law and also established OPR as the coordinating agency in state government for environmental justice (EJ) efforts. The placement of the central EJ program within OPR demonstrates the Legislature’s understanding that EJ efforts require coordination at the highest level of state government. Indeed, California is the only state that has placed its EJ effort within the Chief Executive’s Office.

The legislation establishing OPR as the “coordinating agency in state government for environmental justice programs” (California Government Code § 65040.12) directs the OPR director to consult with state agencies and interested members of the public and private sectors in this state, coordinate its efforts and share information regarding EJ programs with federal agencies, and review and evaluate any information from federal agencies that is obtained as a result of their respective regulatory activities.

This policy report is intended to provide a brief history of EJ, report on the status of OPR's efforts, and provide an outline of EJ findings, goals and policies for future EJ efforts within state government. Much work remains to ensure that the most vulnerable of Californians, including people of color and low-income persons, are treated with dignity and respect regarding environmental decisions. OPR views its work thus far as a modest, although significant beginning.
CHAPTER 1: CONTEXT & HISTORY OF ENVIRONMENTAL JUSTICE

Community organizations and EJ activists spearheaded the environmental justice movement across the country. In essence, the EJ movement was the grass-roots response to both public and private sector actions which oftentimes, either intentionally or unintentionally, targeted communities of color and low income populations and/or excluded such communities from the processes by which environmental decisions were made. Historically, many EJ communities have raised issues related to the unequal enforcement of environmental, civil rights, and public laws; differential exposure of minority and low-income populations to health risks in the home, school, neighborhood, and workplace; and, faulty assumptions by government agencies and private entities in calculating and assessing risks to minority and low-income populations. In addition, discriminatory zoning and land use practices and exclusionary policies and practices have limited the effective participation by minority and low-income residents in governmental processes and have fueled the EJ movement.

Many say that the story of modern EJ movement began in the early 1980’s in Warren County, North Carolina. There, residents fought the location of a toxic waste landfill in a small town where authorities wanted to bury 32,000 cubic yards of soil contaminated with polychlorinated biphenyl (PCB). The town of Afton was both predominantly African-American and low income. Although the landfill was eventually constructed, national attention was brought to the situation where race, poverty, and inequity seemed to intersect.1

Closer to home, in the early 1990’s, national attention was focused on a small community in Kings County, California. Kettleman City hosts the largest toxic waste dump west of Alabama and in 1988, the more than 95% Latino farmworker community was faced with the prospect of the creation of another major toxic waste incinerator in their area. Despite the largely Spanish-speaking community, the Environmental Impact Report of nearly 1,000 pages, initially, was not translated into Spanish, nor were adequate translation services provided at the public hearings. In a subsequent lawsuit, the judge ruled that the Kettleman City residents were effectively precluded from meaningful involvement in the California Environmental Quality Act (CEQA) review process. By September 1993, the project proponent, Chem Waste, withdrew its proposal for the toxic waste incinerator.

The City of Bell Gardens, California (in southern Los Angeles County) also garnered national attention in the 1990’s. An increased risk for cancer, miscarriage, and catastrophic illness brought focus on two chrome plating plants in particular, but also the several factories and plants located in the largely Hispanic, lower income community. The Suva Elementary and Intermediate Schools are located next to one of the metal plating plants. The high pollution concerns caught the attention of California lawmakers who sought to reform health standards to levels that protect children and not just adults. Although the proposed legislation, AB 278 (Escutia), the Children’s Environmental Health Protection Act, was vetoed by then Governor Wilson, the community’s point was proven when the Department of Toxic Substances Control concluded its investigative
report of the elementary school. The investigation found an excessive cancer risk to the population and required the plant to reduce its air emissions.

Although initial EJ efforts focused on traditional permitting and siting situations, current thought is that EJ pertains to all facets of life – where people live, play, work, and go to school.

At the national level, EJ policy was spearheaded on February 11, 1994 when President Clinton signed Executive Order (EO) 12898 regarding “Federal Actions to Address EJ in Minority Populations and Low-Income Populations.” The EO followed a 1992 U.S. EPA report indicating that “communities of color and low-income populations experience higher than average exposures to selected air pollutants, hazardous waste facilities, and other forms of environmental pollution.”

Prior to the passage of recent EJ laws in California, multiple anti-discrimination laws were already in the books. For example, state planning law prohibits any local entity from denying any individual or group of individuals the enjoyment of residence, land ownership, tenancy, or any other land use in California because of the race, sex, color, religion, ethnicity, national origin, ancestry, lawful occupation, or age of the individual or group of individuals (California Government Code § 65008). In addition, the Fair Employment and Housing Act (FEHA) specifically prohibits housing discrimination on the basis of race, color, religion, sex, sexual orientation, marital status, national origin, ancestry, familial status, disability, or source of income (California Government Code §12900 et seq.).

California’s anti-discrimination laws, combined with the more recently passed EJ-specific laws in California, are a potent combination that calls on California state government to avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations; to prevent the denial of, reduction in, or significant delay in the receipt of lawful benefits by minority and low-income populations of California; and to ensure that the full and fair participation by all potentially affected communities in the decision-making processes.
CHAPTER 2: CALIFORNIA’S ENVIRONMENTAL JUSTICE FRAMEWORK

California has remained a national leader in taking the initiative to protect the environment and the public from environmental and health risks. Governor Davis has signed eight EJ-related bills into law over the last five years, resulting in an EJ framework that provides flexibility and encourages state agencies to explore ways to encourage and ensure EJ. As a whole, California’s statutory EJ framework demonstrates a public policy that governmental activities that affect human health or the environment should be conducted in a manner that considers the most vulnerable populations, and ensures that environmental justice principles are adhered to.

In 1999, Governor Davis signed SB 115 (Solis), making California the first state in the nation to codify a definition of “environmental justice.” SB 115 defined EJ as “the fair treatment of people of all races, cultures and income with respect to development, adoption and implementation of environmental laws, regulations and policies” and established OPR as the coordinating agency for state EJ programs. The bill further required the California Environmental Protection Agency (Cal/EPA) to take specified actions in designing its mission for programs, policies, and standards within the agency, and to develop a model EJ mission statement for its boards, departments, and offices.

In September 2000, the Governor signed a related bill, SB 89 (Escutia, 2000), which complements SB 115 by requiring the creation of an EJ working group and a public advisory committee to assist Cal/EPA in developing an interagency EJ strategy. Further, SB 828 (Alarcón, 2000) added due dates for the development of CalEPA’s interagency EJ strategy and required CalEPA to address program obstacles impeding EJ.

In 2001, the Governor signed AB 1553 (Keeley, 2001), which required OPR to create advisory guidelines addressing EJ considerations in the General Plan Guidelines. In short, these guidelines would propose methods for the equitable distribution of new public facilities, public services, industrial facilities and uses, new schools, and residential dwellings, and expanding opportunities for transit-oriented development.

During Legislative Session 2001-02, the Legislature passed and the Governor signed into law several more bills, which establish the balance of the existing EJ framework for California. SB 32 (Escutia, 2001) authorized local governments to investigate and cleanup small parcels of property contaminated with hazardous waste and required the development of a guidance document to assist communities, developers, and local governments in understanding the complicated factors and procedures used for cleaning up hazardous waste. SB 32 also established a pilot project for assessing the usefulness and impact of informational screening numbers, for encouraging the remediation of contaminated property in a study area located in Southern California.

AB 1390 (Firebaugh, 2001) required that air districts with more than one million residents expend specified emission reduction funds in communities with the most significant exposure to air contaminants and in communities of minority and/or low-
income populations, and encouraged districts with less than one million residents to do the same.

**SB 1542 (Escutia, 2002)** required the Integrated Waste Management Board to provide EJ models and information to local jurisdictions for siting landfills. In addition, SB 1542 added four additional representatives to the existing EJ Advisory Committee from two EJ organizations, one federally-recognized Indian Tribe, and one small business association.

**AB 2312 (Chu, 2002)** established an EJ Small Grant Program administered by CalEPA. It will provide grants of up to $20,000 to local community nonprofit organizations for projects that address EJ issues.
CHAPTER 3: OPR’S ENVIRONMENTAL JUSTICE PROJECT

There are over 100 state agencies, departments, boards and commissions in California state government. Named in statute as the coordinating body for EJ work within state government, OPR’s serves as a clearinghouse of information and central point of contact for EJ efforts involving state government. It also serves as a convenor of multi-agency efforts to address issues of mutual concern. Simultaneously, it serves as the means by which positive, successful examples of public sector EJ work are shared throughout state government. OPR has a number of methods by which it accomplishes its work, the most prominent of which are highlighted below.

EJ Coordinating Committee. OPR has formed a Coordinating Committee made up of the directors of all State Agencies, Boards, Departments, and Constitutional Offices to coordinate the State’s EJ efforts. The Coordinating Committee meets quarterly to encourage the state agencies to incorporate EJ into their missions, policies, programs and activities. These meetings have provided state agencies the opportunity to learn about EJ and begin to coordinate their efforts to address EJ issues.

EJ Steering Committee. OPR has also established a steering committee made up of designees of state agency and department directors, which meets monthly to identify ways in which the state can address EJ concerns through statutory, regulatory, or policy and practice reform. The committee makes recommendations to the OPR Director based on its findings. In addition, the steering committee members act as EJ liaisons for their respective departments and agencies and help to achieve a coordinated state response to this very important environmental and civil rights issue.

EJ Listening Sessions & Tours. OPR has encouraged state government officials to learn more about potential EJ issues in their communities by participating in listening sessions and on-site tours. These tours have been led by community-based organizations that coordinate and narrate visits to sites related to EJ issues from the perspective of local community-based organizations. OPR has either participated or organized tours in a number of communities, including Los Angeles, Richmond, San Francisco (Bayview Hunters Point), Daly City (Midway Village), Fort Ord, and Salinas.

Development of Models for Community Partnerships. OPR works with communities across the state to examine ways that State Government can encourage sustainable change in impacted communities of color and/or low-income communities. The Bayview/Hunter’s Point community of Southeast San Francisco is one of those communities. The are more than 300 toxic sites in this community as well as a power plant. More than 70% of the residents are African-American. OPR has convened a working group of stakeholders to identify ways to address the EJ issues presented in this community. The stakeholder group includes government agencies, non-profit organizations, the private sector, and residents. The current focus of this effort is the creation of alliances that will bring clean industries and sustainable job development to the area, as well as studying ways to close down the older power plant units while insuring electrical generation and reliability for the San Francisco Bay Area.
State Agency Policy Development. OPR has worked with various state agencies to develop EJ policies and practices. OPR assists these agencies by sharing information about existing policies, statements, and activities, providing individual consultation to agency officials, and providing feedback on proposed policies. In general, these policies address such areas as public participation and outreach, public access to state agency activities and data, research and data collection, enforcement of applicable statutes, and, employee training. Five state agencies now have adopted EJ policies and/or EJ statements. In addition, several other state agencies are working toward development of policies. Those agencies that have adopted policies or statements include the California Air Resources Board, Department of Transportation (Caltrans), State Lands Commission, Cal/EPA, and the California Bay Delta Authority.

Employee Training. OPR holds monthly one-day workshops to teach state agency personnel about what EJ is, federal and state laws that address EJ, and how to address EJ issues in their work. As of mid-2003, staff from over 50 state agencies and departments has participated in the training. Thus far, nearly 800 state agency employees have been trained regarding the fundamentals of EJ. At the close of 2002, OPR also arranged for staff from five state agencies to attend a five-day, Training for Trainers workshop, developed by the National Environmental Justice Training Collaborative and sponsored by the U.S. EPA, Region IX. Those agencies receiving this advanced training included the California Energy Commission, the Department of Water Resources, the CALFED Bay-Delta Authority, the Department of Toxic Substances Control, and the Department of Health Services.

Cal/EPA EJ Interagency Working Group. OPR is a member of the EJ Interagency Working Group (IWG), established by SB 89 (Escutia, 2000), comprised of the Director of OPR, the Secretary of Cal/EPA, and the directors of each of Cal/EPA’s Boards, Departments and Offices. The IWG is charged with identifying gaps in environmental laws, regulations and policies as they relate to EJ and creating a strategy to address such gaps.

Briefings for State Agencies. Over the last several years, OPR has provided briefings to a multitude of state agencies, departments, boards and commissions. These presentations have typically been geared to the needs of the individual organizations, with special attention paid to the level of management and staff being briefed, as well as the mission and objectives of the organization.

Conferences and Seminars. OPR has actively participated in various conferences and events related to EJ. Of particular importance to OPR have been those seminars and events which speak to the interaction of state agencies to impacted EJ communities of color and low-income persons. Among the notable conferences and seminars in this category is the 2nd National People of Color Environmental Leadership Summit, held in Washington DC in 2002 and the National Summit on Equitable Development, Social Justice and Smart Growth, held in Los Angeles, CA in 2002.
CHAPTER 4: STATE AGENCY ENVIRONMENTAL JUSTICE ACTIVITIES

Since the first EJ legislation was signed, many state agencies and departments have embarked on a broad range of EJ activities. From EJ policy development to publishing handbooks to engage the public in public processes to addressing EJ in environmental documents, these state activities are to be commended for their leadership and helping to lay the foundation for the future of environmental justice. Below are some examples of the most notable efforts.

California Air Resource Board (ARB)
ARB has also taken extraordinary steps to address EJ. ARB was the first state entity to adopt an EJ policy. To date, ARB has taken various steps to implement the policy, including, but not limited to, modeling best-practices for public meetings, publishing a public participation handbook for agencies and the public in both English and Spanish, and developing an Air Quality Handbook on Land Use. The draft Air Quality Handbook on Land Use (Handbook) is intended to serve as a general reference guide for evaluating and reducing air pollution impacts associated with new projects that go through the land use decision-making process. The Handbook was developed with the assistance of OPR and its 2003 General Plan Guidelines. ARB has also convened a multi-stakeholder EJ group to serve as a forum to discuss its EJ program.

California Bay-Delta Authority (CALFED)
Through CALFED’s EJ program, it has made the commitment to address EJ challenges related to the management of water in the Bay-Delta watershed. This commitment has been demonstrated through the establishment of an EJ subcommittee comprised of stakeholders representing people of color and low-income residents of the watershed. The subcommittee has played an active role in disseminating information on water management issues, to EJ communities, including a fact sheet on EJ in both English and Spanish geared towards agencies and the public. CALFED also established an EJ Annual Plan and an EJ Workplan, which outlines a two-tiered approach to addressing a broad set of environmental justice issues in the context of CALFED program implementation. OPR has provided consultation to the Authority in its EJ work.

California Department of Education
The Department’s Office of Environmental Education (OEE) is in the process of developing EJ curriculum for K-12 classrooms that can be applied as a part of the environmental curriculum. OEE has presented the materials to OPR’s EJ Steering Committee for input and consultation. OPR has shared examples of its EJ curriculum with OEE to assist OEE in its efforts.

California Environmental Protection Agency (CalEPA)
CalEPA has established a model EJ program that involves an Interagency Working Group on Environmental Justice, a multi-stakeholder Advisory Committee made up of 17 members to guide program and policy development and to develop an EJ Strategy for the Agency. Following an 18-month public process, the Advisory Committee approved their Recommendations on Environmental Justice by consensus, with one dissenting vote, on
September 30, 2003. The Interagency Working Group, which includes the Office of Planning and Research (OPR), will consider the Recommendations as it develop its EJ Strategy. Additionally, CalEPA is in final phase of writing regulations for an EJ Small Grants Program to support grassroots communities in finding solutions to environmental issues. Other entities within CalEPA have also engaged in EJ activities. For example, the Department of Toxic Substances Control has released a draft EJ policy for public comment.

**California Department of Health Services (DHS)**

In recognition of the possible links between environmental hazards and chronic diseases, DHS has embarked on a historic effort in the state to develop the California Environmental Health Tracking Program (CEHTP). The CEHTP is a collaborative initiative of the Department of Health Services, the Office of Environmental Health Hazard Assessment, and the University of California. It involves the systematic collection, integration, analysis, interpretation, and dissemination of data about environmental hazards and exposure to environmental hazards.

The CEHTP originated with funding from the Centers for Disease Control and Prevention (CDC) to develop a nationwide environmental health tracking network and to increase environmental health tracking capacity within state and local health departments. By developing new information about the links between health and environmental factors, California may be able to replace costly treatment of chronic disease with cost-effective prevention. To date, an expert working group and a planning consortium, including a representative of OPR, has convened to provide guidance for the development of the tracking system. The three-year effort will yield invaluable insight regarding environmental exposures and California communities, including communities of color and low-income persons.

**California Resources Agency**

The Resources Agency has finalized an Environmental Justice Policy that includes a mission statement, background, policy statement, and a framework for its implementation program. In addition, Resources Agency convenes interagency meetings of EJ staff involved to discuss EJ efforts. OPR has provided consultation to Resources in its policy development and as it embarks on phase two of CEQA amendments to address EJ.

Various departments within The Resources Agency have also taken the initiative to address EJ. For example, the Director of the Department of Water Resources has distributed a letter affirming DWR’s commitment to EJ and has also appointed an EJ point-of-contact for all EJ matters. This contact has since received training to conduct the Fundamentals of Environmental Justice training, along with an EJ contact within the California Energy Commission (CEC). DWR has also included EJ as a core training requirement for all DWR staff. Additionally, the California Conservation Corps (CCC) is taking steps to integrate EJ into its programs and policies. More specifically, the CCC is folding EJ information into their traditional environmental education curriculum.
California Energy Commission (CEC)
The CEC has conducted EJ analyses as part of its certification process for more than 50 large thermal power plants over the past eight years, and also has been an active and long-term participant in the OPR EJ Steering Committee. The CEC has provided presentations on its EJ approach at OPR EJ Coordinating Committee meetings and at various other environmental justice related forums sponsored by government and private entities. The CEC has made many improvements to its EJ analysis approach over the years, and has also begun providing in-house EJ training to its staff.

California State Lands Commission (SLC)
SLC adopted an EJ policy in October 2002 after distributing an interim policy to 51 EJ and community organizations throughout California for comment. In its policy, the SLC “pledges to continue and enhance its processes, decisions, and programs with EJ as an essential consideration.” The policy also cites the definition of EJ in state law and points out that this definition “is consistent with the Public Trust Doctrine principle that the management of trust lands is for the benefit of all of the people.” The SLC was aided in its drafting efforts by OPR, which provided background information and examples of EJ policies and statements from both the public and private sector.

California Department of Transportation (Caltrans)
Caltrans has also proven to be state department that is committed to EJ. Caltrans released a Director’s Policy and a Deputy Directive in November of 2001, which lists specific responsibilities for various levels of staff to address EJ. Caltrans has also administered the Environmental Justice: Context-Sensitive Planning Grant Program over the last three fiscal years. The purpose of this EJ grant is to promote more public involvement by diverse and under-served communities in the planning for transportation projects to prevent or mitigate disproportionate, negative impacts of plans and projects while improving their mobility, access, equity, and quality of life. Outside state agency staff also assist in reviewing these EJ grant application, including the OPR. OPR has also assisted Caltrans in providing EJ training to local communities.

California State and Consumer Services Agency
The State and Consumer Services Agency (SCSA), encompassing twelve departments, commissions, and boards, has been an active participant in the OPR EJ Steering Committee. The SCSA has sponsored an EJ briefing for its Executive Team. SCSA houses such key entities as the Departments of General Services and Fair Employment and Housing. Both departments have participated in OPR's EJ training course.

In addition, the Department of Consumer Affairs, Bureau of Automotive Repair (BAR), which implements California's Smog Check program, has made its "Smog Check Assistance Program" accessible to low-income communities in California through a targeted outreach effort. Its Assistance Program pays up to $500 in emissions-related diagnostic and repair services to those car owners who meet eligibility criteria. The program assists in removing tons of harmful pollutants from the air. BAR staff have taken the program to specific areas of the state, not usually benefiting from the program, including inner cities and the Central Valley.
Chapter 5: Environmental Justice and Social Equity

During our lifetimes, the state’s population has grown at an unprecedented pace: the change in the racial and ethnic composition of the population has been more than dramatic. Indeed both changes have happened within a very narrow window of time.

More than 40 percent of California’s diverse population of 34 million people are now people of color. Major ethnic groups include Hispanic (32.4%), Asian (10.9%), and African American (6.7%). In addition, California has a significant Native American population, whose culture and religious practices have implications for the type of environmental activities that lie at the hear of OPR’s planning and policy development responsibilities.

The demands on state government to address the challenges of such growth and change are enormous. How do we meet such needs as housing, workforce development, education, and environmental protection so that California can continue to thrive? And just as importantly, how can we promote a synergy among the environment, the economy and the people to create sustainable change. In a nutshell, EJ can be said to be the vision and process of creating socially just, sustainable human and ecological systems. With California being the largest economy in the nation and the fifth largest in the world, much is at stake. OPR has also engaged in numerous activities to explore the relationship between environmental justice, social equity and sustainability. Below is a summary of some of these activities.

EJ Forums. In January and February of 2002, OPR hosted four EJ Forums around the state. These Forums were an opportunity for OPR and its partner state agencies to hear first-hand information from EJ communities and Tribes as to how government can improve public processes to encourage public participation in governmental decision making. The comments received during the Forums proved to be invaluable to the development of the General Plan Guidelines discussed below.

General Plan Guidelines. For the first time, EJ concepts and considerations are addressed in the general plan guidelines, as required by AB 1553 (Keeley, 2001). This is particularly important given the fact that land-use decisions can oftentimes be used to promote or discourage EJ efforts. Although, as noted above, the original EJ movement was focused on permitting and siting decisions by government agencies, most EJ advocates today define EJ broadly. These advocates have moved the EJ concept beyond the tie to the natural environment, and apply it to virtually all aspects of peoples’ lives – where people live, work, play, and learn. Thus, from this
As the primary agency with responsibility for approving changes in boundaries, LAFCOs play an important role in coordinating growth and ensuring that proposed changes are consistent with environmental justice obligations.

LAFCO Guidelines. Local Agency Formation Commissions (LAFCO) are quasi-legislative local agencies created in 1963 to assist the state in encouraging the orderly development and formation of local agencies. LAFCOs were created to act, where appropriate, to minimize the effects of unchecked urban sprawl upon finite prime agricultural and open space land resources, through their decisions on city incorporations, city annexations, and service district boundary changes. AB 2838, the Cortese-Knox-Hertzberg Local Government Reorganization Act of 2000 (CKH Act) made substantial changes to how LAFCO’s operate and increased the specific authorities and responsibilities of LAFCOs related to environmental justice and smart growth. OPR was charged with developing guidelines for LAFCOs to follow when considering city incorporations and municipal service reviews.

The 2003 Municipal Service Review (MSR) Guidelines describe the framework for developing an effective municipal review process which reflects the laws and policies related to civil rights and environmental justice. EJ has implications for municipal service reviews, as the nine determinations relate to the provision of services to whole communities including those that may have been historically underserved and/or environmentally overburdened.
The 2003 MSR Guidelines address EJ by encouraging greater transparency in the LAFCO decision making process through greater public participation and education, clearly articulated local policies and procedures, minimum public review periods, and adoption of a long range work plan. The 2003 MSR Guidelines also encourage multi-county service reviews where appropriate, and incorporation of municipal service reviews with other LAFCO approvals/actions. The guidelines also encourage LAFCOs to act as facilitators for community concerns, recognize communities of interest, and incorporate municipal service reviews with other LAFCO approvals/actions.

The Environmental Goals & Policy Report. The Governor is required to prepare a comprehensive State Environmental Goals and Policy Report (EGPR) every four years. The report must contain: (a) A long-range (20-30 year) overview of state growth and development; (b) A statement of approved state environmental goals and objectives, including those directed to land use, population growth and distribution, development, conservation of natural resources, and air and water quality; and (c) A description of new and revised state policies, programs, and other actions of the executive and legislative branches required to implement the approved goals. The goals included in the EGPR must be consistent with the three state planning priorities established under AB 857 (Wiggins, 2002), which are intended to promote equity, strengthen the economy, protect the environment, and promote public health and safety in the state, including in urban, suburban, and rural communities. These priorities are to: (1) promote infill development and equity; (2) protect environmental and agricultural resources; and (3) encourage efficient development patterns.

The 2003 EGPR marks the first time in 25 years that a Governor of California has attempted to address the issue of growth and development on a statewide scale. It analyzes the current context of our environmental, economic and social setting; the driving forces behind growth and development; and the outside influences that affect many of the State's actions, policies, and programs. Based on this analysis of existing conditions and influences, the EGPR proposes several cross-cutting and integrated goals and policies for the State of California which will allow it to achieve the overarching goal of sustainable development.

The 2003 EGPR addresses EJ in the context of the bigger social equity problem. Sustainable development is discussed as an attempt to reduce the negative impacts associated with development of our land and our communities. It does this by attempting to balance the effects of development on the environment, the economy and equity, or the “Three Es”. Equity is the least understood and most overlooked of these three, perhaps because it is the hardest to define and measure. Equity is achieved when community resources are equally distributed to, and accessible by all segments of the population. Equity is often referred to as social equity, but the topic of equity includes economic and social equity, and environmental justice.
environmental issues when they are related to quality of life. The 2003 EGPR recognizes EJ in terms of environmental inequity. It also reveals that health problems are only exacerbated by low wages, lack of educational attainment, poor housing conditions, poor access to health care facilities, and environmental injustice.
CHAPTER 6: ENVIRONMENTAL JUSTICE FINDINGS, GOALS, AND POLICIES

California’s environmental justice efforts are no longer in its infancy stages. Rather, the Legislature and public agencies have laid a foundation that is strong, embarked on public processes that are thriving, and developed relationships that are continuing to grow. This momentum must continue. To ensure the continued direction toward environmental justice, state agencies must consider the following goals and policies in their respective programs, policies, medium- and long-range plans, and environmental decision-making.

Acting in OPR’s statutory role as the coordinating agency in state government for environmental justice programs (Government Code § 65040.12), following is a listing of findings by OPR in its work with various public agencies.

FINDINGS

♦ EJ issues involve emotion, race, poverty and power; raise broad community concerns; are sometimes difficult to identify; usually cross government agency boundaries; often reveal a lack of trust in institutions; take time and excellent communication skills; do not lend themselves to any “one” solution; often involve legal authorities and legal challenges; and often present complex environmental and economic issues.

♦ An effective EJ program will address at least five programmatic areas, including leadership and accountability, planning and priority setting, adequate allocation of resources, public participation and capacity building with communities, and sustainability.

♦ State agencies have significant flexibility to move beyond meeting minimum environmental requirements and can employ their discretionary decision-making in creative and appropriate ways to address EJ issues within their purview.

♦ Those state agencies that have made the most progress:
  ▪ Have developed or are in the process of developing long-term partnerships with the communities they serve. In this case, this includes the collaborative participation of local government officials, the business and academic communities, and EJ advocates and residents;
  ▪ Have been willing to ask themselves the oftentimes difficult questions of who gains benefits and who loses benefits by proposed actions or decisions; and
  ▪ Have been willing to identify at-risk communities and target their resources to those communities. Those same state agencies have begun to examine their own data collection practices to determine whether or not they need to gather data at new or different levels than previously done.

The goals and policies set forth below are in part a response to OPR’s findings and in part echoed in some of the recommendations adopted by the Cal/EPA EJ Advisory Committee
and subsequently endorsed by the Cal/EPA Interagency Working Group on a conceptual level as they developed their agencywide EJ strategy.

OBJECTIVE
To ensure the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.

GOAL 1
A state government that is inclusive and responsive to people of all races, cultures and incomes with respect to development, adoption and implementation of environmental laws, regulations and policies.

Policy A
The state shall promote meaningful public participation.

Action Items
- OPR shall provide state agencies and other interested parties with criteria, guidelines, and technical assistance for successful meaningful public participation programs.

Policy B
The state shall promote community capacity building to allow affected communities and interested individuals to be effective participants in the development of state plans and policies, and decision-making processes.

Policy C
The state shall encourage increased civic engagement through increased public access to information, technical assistance, and resources necessary for meaningful participation in the development of state plans and policies, and decision-making processes.

Policy D
The state shall encourage the collaboration between public agencies and community-based organizations, community adult-education programs and youth development groups in order to increase awareness and engagement by under-represented groups in the development of government plans and policies, and decision-making processes.

Action Items
- OPR shall extend staff training opportunities to stakeholders, including state and local agencies that interact with communities on EJ-related issues.

GOAL 2
A state where people of all races, cultures and incomes are ensured a healthy environment.

Policy A
The state shall integrate environmental justice into the development, adoption and implementation of environmental laws, regulations and policies.

Action Items
• OPR shall provide offer training to state agencies and other interested parties on the fundamentals of environmental justice.
• OPR shall collaborate with other state agencies to tailor environmental justice training for technical staff (e.g., those responsible for power plant permitting, etc.)
• OPR shall conduct an annual survey of state agencies of their year-to-date EJ activities.
• OPR shall convene a conference of all state agencies to examine their progress toward EJ with a focus on how they can contribute to capacity building with ethnic and low-income communities so that the communities can be full partners with state government in identifying and meeting EJ challenges.
• Appropriate state agencies and departments shall collaborate with local governments, federal agencies, environmental justice and community groups

Policy B
The state shall encourage the approach that it is not necessary or appropriate to wait for actual, measurable harm to public health or the environment before evaluating alternatives that can prevent or minimize harm.

Policy C
The state shall examine the possibility of developing EJ-related language for the next update to the CEQA Guidelines.

GOAL 3
A state with environmental justice leadership and stewardship across all state agencies.

Policy A
The state shall make a commitment to achieving environmental justice.

Action Items
• The Governor shall release an executive order expressing California’s commitment to environmental justice.
• The Director of OPR shall release implementation and technical guidance in order to assist state government agencies.

Policy B
The state shall ensure effective cross-media coordination in addressing environmental justice issues.
APPENDICES
### California State Government Environmental Justice Contacts

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STATE OF CALIFORNIA
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

INTERAGENCY WORKING GROUP ON ENVIRONMENTAL JUSTICE

RESOLUTION

October 14, 2003

WHEREAS, the California Environmental Protection Agency (Agency) Interagency Working Group on Environmental Justice (IWG) – consisting of the Secretary of the Environmental Protection Agency (Secretary), the Chairpersons of the California Air Resources Board, the State Water Resources Control Board and the Los Angeles Integrated Waste Management Board, and the Directors of the Office of Environmental Health Hazard Assessment, the Department of Toxic Substances Control, and the Department of Alcohol and Beverage Control, and the Director of the Governor's Office of Planning and Research – was established by Public Resources Code section 71114 and convened by the Secretary for the purpose of developing an environmentally just strategy for the Agency.

WHEREAS, the California Environmental Justice Advisory Committee (Committee) consisting of 17 members representing the perspectives of land use planning agencies, air pollution control districts, Certified United Program Agencies, non-profit organizations, large and small businesses, community organizations, and Federally recognized Indian tribes and environmental justice organizations was established by Public Resources Code section 71114 and appointed by the Secretary for the purpose of advising the IWG concerning the development of the Agency Environmental Justice Strategy.

WHEREAS, the Committee has conducted an extensive process to solicit and consider public input into its recommendations and advice to the IWG concerning the issues to be addressed, goals to be set, and actions to be taken concerning environmental justice and the development of the Inter-Agency Strategy, and has developed and presented to October 1, 2003 a comprehensive Report and Recommendations to the IWG.

WHEREAS, the members of the IWG have reviewed the Committee Report and Recommendations and having considered their at an open and public meeting and following hearing of public comment and input on October 14, 2003, accept the Report.
and Recommendations from the Committee and they support the concepts included in the four goal statements in the report:

1. Ensure meaningful public participation and promote community capacity building to allow communities to be effective participants in decision-making processes.

2. Integrate environmental justice into the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.

3. Improve research and data collection to promote and address environmental justice related to the health and environment of communities of color and low-income populations.

4. Ensure effective cross-sector coordination and accountability in addressing environmental justice issues.

WHEREAS, the EWG agrees with the concepts contained in the various recommendations included in the Committee's report and stands, with all its legal authority to do so and its resources as law, to implement those recommendations for the Agency and its SDO's deemed not to be reasonable and feasible.

WHEREAS, the EWG finds that:

The Committee Report and Recommendations is substantially consistent with the requirements of Public Resources Code section 11313(b) that requires the EWG, with the help of the Committee:

1. Examine existing data and studies on environmental justice and consult with state, federal, local agencies, and affected communities.

2. Recommend revisions to the Secretary for Environmental Protection for identifying and addressing any gaps in existing programs, policies, or activities that may impede the achievement of environmental justice.

3. Recommend procedures and provide guidance to the California Environmental Protection Agency for the coordination and implementation of new agency environmental justice strategies.

4. Recommend procedures for collecting, maintaining, analyzing, and using existing information related to an environmental justice strategy.

5. Recommend procedures to ensure that public documents, notices, and public hearings related to human health or the environment are concise, understandable, and easily accessible to the public. The recommendations shall include guidance for document when it is appropriate for the State Environmental Protection Agency to translate public documents, notices, and hearings related to human health or the environment for limited English-speaking populations.
16) Hold public meetings to receive and respond to public comments regarding recommendations contained in this section, prior to the finalization of the recommendations. The California Environmental Protection Agency shall provide public notice of the availability of draft recommendations at least one month prior to the public meetings.

17) Make recommendations or other matters needed to assist the agency in developing an intra-agency environmental justice strategy.

NOW, THEREFORE BE IT RESOLVED that, the PUC endorses the Committee report and agrees to use the data and recommendations contained in it to provide the structure for development of the Inter-Agency Environmental Justice Strategy.

BE IT FURTHER RESOLVED that the PUC will work with the Committee to develop the strategy document by not later than December 1, 2003, including implementation plans that set out the steps the agency, each EDCO and UPA, will individually and collectively as appropriate, take to begin working toward achievement of the goals set out in the report.

The undersigned Interagency Working Group on Environmental Justice staff certify that the signing is a true, and a copy of a resolution duly and regularly adopted at a meeting of the Interagency Working Group held in Sacramento, California on October 15, 2003.

[Signatures]

Secretary, California Environmental Protection Agency & Chair, Interagency Working Group on Environmental Justice

Inspector, Governor’s Office of Planning & Research

Director, Department of Water Resources

Director, Department of Water Resources

Director, Office of Environmental Waste Reduction & Removal
OPR Environmental Justice Workshops

WHEN: Every Fourth Tuesday of each Month
9:00 a.m. to 5:00 p.m.

WHERE:
Gregory Bateson State Office Building
Office of Statewide Health Planning & Development
1600 Ninth Street, Rm. 470
Sacramento, CA

The Governor’s Office of Planning and Research (OPR) conducts a one-day Environmental Justice workshop on the Fourth Tuesday of each month. According to California law, Environmental Justice (EJ) is the “fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation and enforcement of environmental laws and policies.” (Government Code § 65040.12(c))

These free workshops are geared primarily towards California State agency and department heads, their designees, and key personnel. These workshops are NOT lectures, so be prepared to roll up your sleeves and get actively involved. We will be addressing issues such as:

- What is environmental justice?
- Why should I care?
- What functions does my agency or department perform that may have significant effects on the environment and human health regardless of whether such functions are traditionally thought of as environmentally related?
- How can my agency better ensure that Californians who are of color or are poor are not disproportionately burdened by environmental hazards?
- What are other state agencies doing to implement environmental justice in their work?

The Workshops are free to State agency personnel. Space is limited, so if you are interested, please RSVP your reservation to Tricia Valenzuela at Tricia.Valenzuela@opr.ca.gov. Light reading and a survey will be assigned by e-mail prior to the workshop after receipt of your e-mailed RSVP. If you have special accommodation or language needs, please contact Tricia Valenzuela at 322-3932. Thank you.
Environmental Justice Resource List

Studies & Reports

- **Environmental Justice: A Review of State Responses 2001**
  In an effort to provide guidance to the California Environmental Justice Workgroup in implementing SB 115, this report provides a brief overview of the federal environmental justice framework and a more comprehensive look at state environmental justice programs.
  [http://www.uchastings.edu/plri/PDF/environjustice.pdf](http://www.uchastings.edu/plri/PDF/environjustice.pdf)
- **EJ in Los Angeles**
  [http://www.bol.ucla.edu/~ajays](http://www.bol.ucla.edu/~ajays)
- **Brookings Institute on EJ**
  [http://www.brook.edu/gs/envjustice/ej_hp.htm](http://www.brook.edu/gs/envjustice/ej_hp.htm)
- **National Academy of Public Administration – Environmental Justice in EPA Permitting**

State Links

- **Governor’s Office of Planning and Research – Environmental Justice**
  [http://www.opr.ca.gov](http://www.opr.ca.gov) (EJ on right hand side of webpage)
- **California Environmental Protection Agency Environmental Justice Program**
  [http://www.calepa.ca.gov/EnvJustice](http://www.calepa.ca.gov/EnvJustice)
- **Caltrans, Office of Policy Analysis and Research – Environmental Justice Grants**
  [http://www.dot.ca.gov/hq/tpp/offices/opar/titleVI.htm](http://www.dot.ca.gov/hq/tpp/offices/opar/titleVI.htm)

Federal Links

- **CALFED Bay-Delta Program**
  [http://calfed.ca.gov](http://calfed.ca.gov)
  - CALFED Agencies
    [http://calfed.ca.gov/adobe_pdf/CALFED_Agencies1.pdf](http://calfed.ca.gov/adobe_pdf/CALFED_Agencies1.pdf)
- **Federal Agency Environmental Justice Information**
  [http://es.epa.gov](http://es.epa.gov)
- **National Environmental Justice Advisory Council**
- **U.S. Department of the Interior (DOI)**
  [http://www.doioeopc/nej2.html](http://www.doioeopc/nej2.html)
- **U.S. Department of Transportation, Federal Highway Administration/Federal Transit Administration (FHWA/FTA)**
- **U.S. EPA Office of Environmental Justice**
  [http://es.epa.gov/oeeca/main/nej2](http://es.epa.gov/oeeca/main/nej2)
- **U.S. EPA, Office of Solid Waste & Emergency Response (OSWER)**
  [http://www.epa.gov/swerosps/nej2.html-doc/nej2policy.htm](http://www.epa.gov/swerosps/nej2.html-doc/nej2policy.htm)
• U.S. EPA Region 9 Environmental Justice Program
  http://www.epa.gov/region09/cross_pr/eq
• U.S. EPA – Environmental Justice Small Grants Program
  http://es.epa.gov/oeca/oej/grlink1.html

California Environmental Justice Legislation
• Assembly Bill 970 (Ducheny, Statutes of 2000)
• Assembly Bill 1390 (Firebaugh, Statutes of 2001)
• Assembly Bill 1553 (Keeley, Statutes of 2001)
• Assembly Bill 857 (Wiggins, Statutes of 2002)
• Assembly Bill 2312 (Chu, Statutes of 2002)
• Senate Bill 115 (Solis, Statutes of 1999)
• Senate Bill 89 (Escutia, Statutes of 2000)
• Senate Bill 32 (Escutia, Statutes of 2001)
• Senate Bill 828 (Alarcon, Statutes of 2001)
• Senate Bill 1542 (Escutia, Statutes of 2002)

Suggested changes or additions? Please let us know:
• Sandra Salazar-Thompson, OPR Environmental Justice Program Director
  Sandra.Salazar-Thompson@opr.ca.gov
  (916) 324-6660
• Bonnie Chiu, OPR Environmental Justice Program Assistant Director
  Bonnie.Chiu@opr.ca.gov
  (916) 323-9033
Senate Bill No. 115

CHAPTER 690

An act to add Section 65040.12 to the Government Code, and to add Part 3 (commencing with Section 72000) to Division 34 of the Public Resources Code, relating to environmental quality.

[Approved by Governor October 6, 1999. Filed with Secretary of State October 10, 1999.]

LEGISLATIVE COUNSEL’S DIGEST

SB 115, Solis. Environmental justice.

Under existing law, the Office of Planning and Research serves the Governor and his or her Cabinet as staff for long-range planning and research, and is the comprehensive state planning agency. Existing law, the California Environmental Quality Act, requires the office to prepare, and the Secretary of Resources to certify and adopt, guidelines for use in implementing the act.

Existing law establishes the California Environmental Protection Agency, which is responsible for enhancing the state’s protection of the environment.

This bill would provide that the office is the coordinating agency in state government for environmental justice programs. The bill would require the Director of Planning and Research to consult with the secretaries of specified state agencies, and other parties to coordinate the office’s efforts and, share specified information with certain federal agencies, and review and evaluate other federal information, as provided. The bill would define “environmental justice” to mean the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws and policies. The bill would require the California Environmental Protection Agency to take specified actions in designing its mission for programs, policies, and standards within the agency, and to develop a model environmental justice mission statement for boards, departments, and offices within the agency, by January 1, 2001.

The people of the State of California do enact as follows:

SECTION 1. Section 65040.12 is added to the Government Code, to read:

65040.12. (a) The office shall be the coordinating agency in state government for environmental justice programs.

(b) The director shall do all of the following:

The people of the State of California do enact as follows:

SECTION 1. Section 65040.12 is added to the Government Code, to read:

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65040.12. (a) The office shall be the coordinating agency in state government for environmental justice programs.

(b) The director shall do all of the following:

The people of the State of California do enact as follows:

SECTION 1. Section 65040.12 is added to the Government Code, to read:

65040.12. (a) The office shall be the coordinating agency in state government for environmental justice programs.

(b) The director shall do all of the following:
(1) Consult with the Secretaries of the California Environmental Protection Agency, the Resources Agency, the Trade and Commerce Agency, the Business, Transportation, and Housing Agency, any other appropriate state agencies, and all other interested members of the public and private sectors in this state.

(2) Coordinate the office’s efforts and share information regarding environmental justice programs with the Council on Environmental Quality, the United States Environmental Protection Agency, the General Accounting Office, the Office of Management and Budget, and other federal agencies.

(3) Review and evaluate any information from federal agencies that is obtained as a result of their respective regulatory activities under federal Executive Order 12898.

(c) For the purposes of this section, “environmental justice” means the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.

SEC. 2. Part 3 (commencing with Section 72000) is added to Division 34 of the Public Resources Code, to read:

PART 3. ENVIRONMENTAL JUSTICE

72000. The California Environmental Protection Agency, in designing its mission for programs, policies, and standards, shall do all of the following:

(a) Conduct its programs, policies, and activities that substantially affect human health or the environment in a manner that ensures the fair treatment of people of all races, cultures, and income levels, including minority populations and low-income populations of the state.

(b) Promote enforcement of all health and environmental statutes within its jurisdiction in a manner that ensures the fair treatment of people of all races, cultures, and income levels, including minority populations and low-income populations in the state.

(c) Ensure greater public participation in the agency’s development, adoption, and implementation of environmental regulations and policies.

(d) Improve research and data collection for programs within the agency relating to the health of, and environment of, people of all races, cultures, and income levels, including minority populations and low-income populations of the state.

(e) Identify differential patterns of consumption of natural resources among people of different socioeconomic classifications for programs within the agency.

72001. On or before January 1, 2001, the California Environmental Protection Agency shall develop a model
Environmental justice mission statement for boards, departments, and offices within the agency. For purposes of this section, environmental justice has the same meaning as defined in subdivision (c) of Section 65040.12 of the Government Code.
APPENDIX F

STATE AGENCY EJ POLICIES

California Environmental Protection Agency (Cal/EPA)
Air Resources Board (ARB)
Department of Pesticide Regulation (DPR)
Department of Toxic Substances Control (DTSC)

California Resources Agency
California Bay-Delta Authority (CALFED)
State Lands Commission (SLC)

California Department of Transportation (Caltrans)
MEMORANDUM

TO: All CalEPA Employees

FROM: Winston H. Hickox
Agency Secretary

DATE: March 20, 2002

SUBJECT: CalEPA’s Commitment to Environmental Justice

California has long been a leader in taking initiative to reduce environmental and public health risks posed by air and water pollution, solid and hazardous waste management, and pesticide application. In this tradition, our Golden State stands as one of the nation’s leaders on the issue of environmental justice. Being one of the first states in the Nation to have passed legislation to deny environmental justice in state statute; in fact Governor Davis signed six bills related to environmental justice since 1999.

CalEPA is firmly committed to the achievement of environmental justice. Environmental justice for all Californians is an Agency priority.

Accordinly, we must continue to seek opportunities to implement environmental justice principles, especially those with a concerted, cross-media approach to ensure the integration of environmental justice into all programs, policies, and activities within our Boards, Departments, and Offices (BDOs).

Our environmental justice mission reflects the Agency’s commitment to this issue.

“To accord the highest respect and value to every individual and community, the CalEPA and its BDOs shall conduct our public health and environmental protection programs, policies and activities in a manner that is designed to promote equality and afford fair treatment, full access and full protection to all Californians, including low income and minority populations.”

The energy challenge facing California, as well as every Californian, needs to have immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, check out www.energyoffice.ca.gov.
All Cal/EPA Employees
March 29, 2002
Page 2

SUBJECT: CAL/EPA'S COMMITMENT TO ENVIRONMENTAL JUSTICE

As I've stated before, "Protecting human health and the environment is a job that is never done" and indeed, the opportunities for analysis and action for environmental justice in California are varied and great. The goal of our mission will be attained when all Californians, regardless of race, culture, or income, enjoy the same degree of protection from environmental and health hazards and equal access to our decision-making processes.

Environmental justice is defined in statute as, "The fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations and policies" (Government Code Section 65040.12).

Statute obligates the Agency and its BDOs to do the following:

- Conduct all programs, policies and activities within Cal/EPA and it’s BDOs in a manner that ensures the fair treatment of people of all races, cultures, and income levels, including minority populations and low-income populations of the State;

- Promote enforcement of all health and environmental statutes within its jurisdiction in a manner that ensures the fair treatment of all Californians, irrespective of race, culture, and income;

- Ensure greater public participation from environmental justice stakeholders in the development, adoption, and implementation of environmental regulations and policies;

- Improve research and data collection for programs relating to the health and environment of people of all races, cultures, and income levels, including minority populations and low-income populations of the State;

- Identify among people of different socioeconomic classifications differential patterns of consumption of natural resources for our programs.

Clearly, there is no one simple solution to environmental injustice, but rather a host of existing procedural and programmatic tools available to address the issue. In order to achieve meaningful environmental justice, we should, as a procedural and practical matter
A1. Cal/EPA Employees  
March 28, 2002  
Page 3  

SUBJECT  CAL/EPA's COMMITMENT TO ENVIRONMENTAL JUSTICE

- Enhance our mechanisms for public involvement and input at all levels of the decision-making process to ensure early, accessible, and meaningful participation of all stakeholders (e.g., fact sheets, availability of language translation, and enhanced public outreach);

- Invest in capacity development of all stakeholders, particularly those historically not engaged in the decision-making process (e.g., technical assistance at the community level and leveraging of resources to support local environmental justice efforts);

- Explore opportunities to address environmental justice within current statutory and regulatory structures and identify any necessary changes or clarifications;

- Create partnerships with stakeholders in the environmental decision-making process, understanding that environmental justice requires a collaborative approach at all levels;

- Utilize research and proactive tools and approaches to environmental justice issues such as cumulative impact analysis and pollution prevention to inform how we prioritize, develop, and implement our efforts to reduce and/or eliminate environmental pollution and deliver the benefits of environmental protection; and

- In light of our State's current economic situation, we must be more vigilant in ensuring environmental justice remains a priority and resources continue to be directed to this key issue.

I have asked each of the Boards, Departments, and Office to incorporate environmental justice into their overall strategic plans. This has been accomplished and now we need to move forward in earnest to implement those plans. To assist in our efforts, there are a number of resources I recommend you become familiar with and take advantage of as follows:

- The Interagency Working Group on Environmental Justice (IWG): I chair this Group along with the Governor's Office of Planning and Research Director, including all the heads of the Boards, Departments, and Office within Cal/EPA. The IWG is responsible for guiding programmatic and policy development related to environmental justice.
SUBJECT: CAL/EPA'S COMMITMENT TO ENVIRONMENTAL JUSTICE

- The External Cal/EPA Advisory Committee on Environmental Justice: This Committee is made up of various EJ stakeholders from community groups, environmental organizations, business, local/regional planning agencies, air districts, and Certified Unified Program Agencies to provide advice and consultation on environmental justice to Cal/EPA.

- The Cal/EPA Environmental Justice Website (www.calapa.ca.gov/envjustice/). The website contains the most current information on environmental justice concerns including a Calendar of Events on environmental justice occurring throughout the state.

- Cal/EPA Environmental Justice Fundamentals Training Program (http://www.epa.gov/envjustice/training). The training is offered at various times throughout the year to bring greater awareness of environmental justice issues with Cal/EPA.

Let's continue to work in this spirit to ensure environmental justice is not a series of paper exercises, but a tangible goal attained for and by all Californians. The Assistant Secretary for Environmental Justice, Romel Pascual, and his staff are available to assist you. Mr. Pascual can be reached at (916) 324-8425 or via email at r.pascual@calapa.ca.gov.

I appreciate your continued support in this matter.
POLICIES AND ACTIONS
FOR
ENVIRONMENTAL JUSTICE

Approved on December 13, 2001
INTRODUCTION

The California Air Resources Board (ARB/Board) is committed to making the achievement of environmental justice an integral part of its activities. State law defines environmental justice as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. The Board approved these Environmental Justice Policies and Actions (Policies) on December 13, 2001, to establish a framework for incorporating environmental justice into the ARB’s programs consistent with the directives of State law. These Policies apply to all communities in California, but recognize that environmental justice issues have been raised more in the context of low-income and minority communities. A number of specific actions support each Policy.

While these Policies focus on ARB as an organization, they also reflect the need for the local air pollution control and air quality management districts (local air districts) and other local agencies to play their part. The local air districts are most directly responsible for the regulation of air pollution from businesses and industries in California. Local land-use agencies are directly responsible for the siting of new air pollution sources, and local air districts also play an important role by issuing permits for new sources of air pollution. We are committed to working as partners with these agencies to improve the available information that local agencies use to make planning and permitting decisions. We are also committed to continuing our aggressive program to control motor vehicle pollution, the principal source of air toxics and other emissions leading to the violation of clean air standards. By working together to improve siting and mitigation practices, and further controlling sources within ARB’s jurisdiction, we can help address environmental justice issues at the community level throughout California.

Over the past twenty years, ARB, local air districts, and federal air pollution control programs have made substantial progress towards achieving federal and State air quality standards. These achievements have reduced the exposures of California’s residents to air pollution. Remarkably, during this same period, the State population has increased almost 45 percent and the daily number of vehicle miles traveled in the State has increased almost 90 percent.

REDUCTIONS IN AIR POLLUTANTS *

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>1980 – 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone</td>
<td>-53%</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>-35%</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>-21%</td>
</tr>
</tbody>
</table>

* Ambient air quality standards exist for these air pollutants; statewide average, as measured by air monitoring stations.
+ State ambient air quality standard achieved in all but a portion of Los Angeles County and the City of Calexico.

1 Senate Bill 115, Solis, 1999; California Government Code § 65040.12(c).
Despite this progress, many areas in California still exceed health-based air quality standards for ozone and particulate matter. Air monitoring shows that over 90 percent of Californians breathe unhealthy levels of one or both of these air pollutants during some part of the year. Attaining the health-based standards for ozone and particulate matter is essential to protect the health of all Californians.

Statewide health risk from the most widespread toxic air pollutants has also been substantially reduced through the combined efforts of ARB and local air district actions. Nevertheless, there is a general consensus that the statewide health risk posed by toxic air pollutants remains too high. In addition, some communities experience higher exposures than others as a result of the cumulative impacts of air pollution from multiple mobile, commercial, industrial, and other sources.

The Board shall dedicate resources and work with local air districts to develop narrowly tailored remedies to reduce emissions, exposures, and health risks in communities. The ARB’s Diesel Risk Reduction Program is our most important priority for reducing toxic air pollutants because particulate matter from diesel-fueled engines accounts for 70 percent of the known cancer risk in communities that is attributed to exposure to toxic air pollutants. This Program alone is designed to achieve a 75 percent reduction in the emissions and associated health risk by 2010. However, other control efforts will be necessary to address the health risks posed by toxic air pollutants. We will continue to prioritize our efforts to reduce cumulative emissions of toxic air pollutants by considering the public exposure to, and the health risk caused by, those toxic air pollutants.

Underlying these Policies is a recognition that we need to engage community members in a meaningful way as we carry out our activities. People should have the best possible information about the air they breathe and what is being done to reduce unhealthful air pollution in their communities. In particular, we will work to make information related to air pollution and community health more accessible to the residents of low-income and minority communities so that they can take a more active role in decisions affecting air pollution in their communities. We are also committed to working with local air districts to enhance existing complaint-resolution processes, and to listen to and, as appropriate, act upon community concerns.

These Policies are intended to promote the fair treatment of all Californians and cover the full spectrum of ARB activities. While our primary focus is meeting ambient air

### REDUCTIONS IN TOXIC AIR POLLUTANTS *

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Reduction Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead +</td>
<td>- 95%</td>
</tr>
<tr>
<td>Benzene</td>
<td>- 67%</td>
</tr>
<tr>
<td>Hexavalent Chromium</td>
<td>- 59%</td>
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<tr>
<td>Perchloroethylene</td>
<td>- 59%</td>
</tr>
<tr>
<td>1,3-Butadiene</td>
<td>- 45%</td>
</tr>
<tr>
<td>Diesel Particulate</td>
<td>- 40%</td>
</tr>
<tr>
<td>Methylene Chloride</td>
<td>- 39%</td>
</tr>
</tbody>
</table>

* Identified by the Board as cancer-causing toxic air contaminants; statewide average, as measured by air monitoring stations.

+ 1980–1999
quality standards and reducing health risks from toxic air pollutants, efforts such as air monitoring and research are needed to better understand the connections between air pollution and health. Effective enforcement of air pollution control requirements in all communities is also critical to achieving environmental justice. Education and outreach complete the picture in terms of providing the opportunity for the full participation of all communities. Finally, we recognize our obligation to work closely with all stakeholders—communities, environmental and public health organizations, industry, business owners, other agencies, and all other interested parties—to successfully implement our Environmental Justice Policies.

ARB Policies and Actions for Environmental Justice

I. It shall be the ARB’s policy to integrate environmental justice into all of our programs, policies, and regulations.

As an organization, we will make environmental justice considerations a standard practice in the way we do business. Our programs are comprehensive and include adopting regulations, funding clean air projects through incentive programs, and conducting air monitoring, emissions assessments, employee training, enforcement, research, public outreach, and education. In each program area, we will keep an environmental justice perspective as we set priorities, identify program gaps, and assess the benefits and adverse impacts of our programs, policies, and regulations.

Specific actions include the following:

- Add an explicit discussion of whether proposed major programs, policies, and regulations treat fairly people of all races, cultures, geographic areas, and income levels, especially low-income and minority communities.

- Work with local air districts and stakeholders to address, as appropriate, community concerns about air pollution emissions, exposures, and health risks, including enhanced public outreach.

- Work with stakeholders to review current ARB programs to address potential environmental justice implications and add new or modified elements consistent with these Policies where there are program gaps.

- Develop and incorporate an environmental justice program element into our employee-training curriculum.

- Annually provide a staff briefing to the Board at a public meeting regarding ongoing and planned activities. Issue a written annual status report identifying action items accomplished and a proposed work plan outlining the action items for the next year. The work plan shall include
quantitative goals for emissions reductions and promote the use of pollution-prevention strategies by ARB to achieve those goals.

- Conduct special air-monitoring studies in communities where environmental justice or other air-quality concerns exist, with the goal of assessing public health risks. Compare that information to relevant regional data. Current studies include Oakland, Barrio Logan (San Diego), Boyle Heights, and Wilmington.

- Work with local air districts to develop guidelines for implementation of AB 1390 (Firebaugh, 2001.) (This new law provides that not less than 50 percent of the funds for certain mobile source programs, such as the Carl Moyer Air Quality Standards Attainment Program and programs for the purchase of reduced-emissions school buses, are expended in communities with the most significant exposure to air contaminants, including, but not limited to, low-income and minority communities.)

II. It shall be the ARB’s policy to strengthen our outreach and education efforts in all communities, especially low-income and minority communities, so that all Californians can fully participate in our public processes and share in the air quality benefits of our programs.

We want to enhance the participation of the public in State and local decision-making processes. To accomplish this, we will solicit input from communities, develop additional information on air quality in communities, make this information more accessible, and educate communities on the public process used to make State and local decisions. In partnership with local air districts, we will provide communities, including low-income and minority communities, the opportunity to participate in the decision-making processes.

Specific actions include the following:

- Hold meetings in communities affected by our programs, policies, and regulations at times and in places that encourage public participation, such as evenings and weekends at centrally located community meeting rooms, libraries, and schools.

- Assess the need for and provide translation services at public meetings.

- Hold community meetings to update residents on the results of any special air monitoring programs conducted in their neighborhood.
• In coordination with local air districts, make staff available to attend meetings of community organizations and neighborhood groups to listen to and, where appropriate, act upon community concerns.

• Establish within the Chairman’s Office of Community Health a specific contact person for environmental justice issues.

• Increase public awareness of ARB’s actions in protecting public health through the K-12 education system and through outreach opportunities at the community level.

• Make air-quality and regulatory information available to communities in an easily understood and useful format, including fact sheets, mailings, brochures, and Web pages, in English and other languages.

• Distribute fact sheets in English, and other languages, regarding the Children’s Environmental Health Program, the Community Health Program, and our Environmental Justice Policies.

• Develop and maintain a web-site dedicated to community health that includes information on children’s health issues, neighborhood air monitoring results, pollution prevention, risk reduction, and environmental justice activities.

• Develop and maintain a web-site that provides access to the best available information about sources of air pollution in neighborhoods. Include on the web-site ongoing activities to improve the quality of the information, and note the limitations and uncertainties associated with that information.

• Allow, encourage, and promote community access to the best available information in our databases on air quality, emission inventory, and other information archives.

• Distribute information in multiple languages, as needed, on how to contact the Chairman’s Office of Community Health and our Public Information Office to obtain information and assistance regarding the Board’s EJ programs, including how to participate in public processes.

• Create and distribute a simple, easy-to-read, and understandable public participation handbook.

• Consistent with State statutes, minimize, reduce, and, where practicable, eliminate fees for public information and enhance access to that information, and encourage local air districts to do the same.
III. It shall be the ARB’s policy to work with local air districts to meet health-based air quality standards and reduce health risks from toxic air pollutants in all communities, especially low-income and minority communities, through the adoption of control measures and the promotion of pollution prevention programs.

Preventing and reducing air pollution is the Board’s highest priority. In doing so, we are committed to achieving environmental justice. The public health framework of our efforts to reduce air pollution is the attainment of State and federal ambient air quality standards and reduction of health risks from toxic air pollutants. The framework includes a variety of measures that must be adopted at the local, State, and federal level. As part of these efforts, we must focus on both the regional and neighborhood levels.

In reducing statewide emissions of toxic air pollutants, we will prioritize our efforts by focusing on those pollutants contributing the majority of the exposure and public health risk, including those pollutants identified by the Office of Environmental Health Hazard Assessment under the Children’s Environmental Health Protection Program as potentially causing infants and children to be more susceptible to illness. In the prioritization process, we will consider ARB and local air district air quality assessments and other available data.

Specific actions include the following:

- Develop the ARB Clean Air Plan to assist in the achievement of federal and State ambient air quality standards and to reduce health risks posed by toxic air pollutants.

- Prioritize toxic air pollutant control efforts, including the ARB Diesel Risk Reduction Program, by targeting measures that provide immediate and achievable air-quality benefits, such as emissions reductions from transit buses, refuse trucks, and tanker trucks.

- Develop control measures for other mobile sources of diesel particulate matter.

- Work with local air districts to develop control measures to reduce diesel particulate matter from stationary, portable, and marine diesel engines.

- Review, revise, and develop, as appropriate, modeling tools and control measures for sources of toxic air pollutants that may present significant near-source risks to residents and are common to communities across the State, including consideration of proximity. For example, ARB is reviewing the control measure to reduce
hexavalent chromium from plating facilities and evaluating additional perchloroethylene emission reduction opportunities from dry-cleaning facilities.

- Review existing and evaluate new or revised control measures for toxic air pollutants identified by the Office of Environmental Health Hazard Assessment (OEHHA) under the Children's Environmental Health Protection Program as potentially causing infants and children to be more susceptible to illness. These toxic air pollutants include lead, acrolein, diesel particulate matter, polycyclic organic matter, and dioxins.

- Develop new control measures that will reduce exposure to toxic air pollutants across the State. This analysis will include the consideration of proximity of sources to sensitive populations. Currently under development is an air toxics control measure (ATCM) for formaldehyde from composite wood products. These products are often used in portable buildings and manufactured housing and are of concern due to public exposure and health impacts to children.

- As part of our pollution-prevention efforts, promote and encourage the deployment of zero- and near-zero emissions technologies in communities, especially low-income and minority communities. These technologies include alternate power units for trucks and ZEVs.

- Work with the local air districts to implement incentive programs in communities, especially low-income and minority communities, with the most significant exposure to air pollution, consistent with AB 1390 (Firebaugh).

- Work with local air districts to establish a pilot pollution-prevention outreach program for auto body refinishers to minimize emissions from spray applications.

- Conduct special ambient dioxins monitoring and stationary source-testing study in California.

- Work with the Bureau of Automotive Repair to conduct additional low-income vehicle repair and assistance programs and promote the Smog Check Consumer Assistance Program in low-income and minority communities.
IV. It shall be the ARB's policy to work with the local air districts in our respective regulatory jurisdictions to strengthen enforcement activities at the community level across the State.

The ARB will work with local air districts to improve statewide compliance with all applicable air quality requirements for air pollution sources, whether under ARB or local air district jurisdiction. We want to assure that all complaints are promptly investigated and feedback is provided to the public on actions taken in response to those complaints. We will review our own enforcement activities and redirect efforts where we can achieve a more direct community benefit and will incorporate an environmental justice element into our enforcement training curriculum.

Specific actions include the following:

- In coordination with local air districts and considering input from stakeholders, prioritize field inspection audits to address statewide categories of facilities that may have significant localized impacts and make those audit reports easily accessible to the public.

- Conduct roadside inspections of heavy-duty diesel vehicles in all regions of the State, especially in low-income and minority communities.

- Develop and incorporate an environmental-justice awareness element into our enforcement-training curriculum to promote fair enforcement for all communities.

- Support local air district efforts to ensure that when there is facility noncompliance, the air-pollution-reduction projects or mitigation fees imposed in lieu of penalties will benefit the air quality of the impacted communities.

- Work with the local air districts to develop enhanced complaint-resolution processes for addressing environmental justice issues, including procedures that ARB staff will follow when complaints are made to the ARB.

- Work with the local air districts to improve accessibility of information regarding enforcement activities and actions, including notices of violations, monetary penalties, and other settlements of those violations.

- Assist local air districts on specific issues of community concern.
V. It shall be the ARB’s policy to assess, consider, and reduce cumulative emissions, exposures, and health risks when developing and implementing our programs.

While health risks occur from exposures to cumulative emissions from all sources, motor vehicles are the single, largest contributor on a statewide basis. Current ARB air-quality programs—diesel risk reduction, ozone attainment, particulate matter attainment, zero- or low-emission motor vehicles, air toxics control measures, and consumer products—all help to improve the air quality and reduce cumulative health risks statewide. Nevertheless, current State and federal air quality standards are still exceeded in many areas of California, and there is a general consensus that the statewide health risk posed by toxic air pollutants remains too high. In addition, some communities experience higher exposures than others as a result of the cumulative impacts of air pollution from multiple sources—cars, trucks, trains, ships, off-road equipment, industrial and commercial facilities, paints, household products, and others. We will continue to work with local air districts to reduce emissions as needed to achieve and maintain State and federal air quality standards. For air toxics, we will continue to assess emissions and the associated public exposure and health risk. We will look for new opportunities to reduce cumulative health risk in all communities and to achieve emissions reductions where such reductions are shown to benefit public health, consistent with existing statutory authorities.

We must improve our ability to understand the cumulative public health impacts of air pollution by better assessing emissions, exposures, and health risks within communities. The Office of Environmental Health Hazard Assessment will help us define the health risks for potentially significant toxic air pollutants, and we will reduce emissions where such emissions reductions are shown to benefit public health. We will provide this information publicly in an easily understood way. As many of these activities are dependent upon data available at the local level, we will work very closely with the local air districts to prioritize and focus resources on those activities that will provide the greatest public health benefit.

Specific actions include the following:

- Publicly release and place on the ARB Web-site maps showing estimated cancer health risks on a regional basis, using the best available scientific methodologies and noting the limitations and uncertainty associated with the data and methodologies.

- Develop and place on the ARB Web-site local and regional maps showing air pollution emissions sources using the ARB emission inventory database.

- Develop technical tools for performing assessments of cumulative emissions, exposure, and health risk on a neighborhood scale and
provide maps showing the results at the neighborhood level. Such tools will be validated and peer-reviewed prior to use as a regulatory tool.

- Conduct field studies to support the air quality modeling efforts in communities throughout the State, including low-income and minority communities. Current studies underway include Barrio Logan in San Diego County and Wilmington in Los Angeles County.

- Update mapping data on an ongoing basis.

- Identify necessary ARB risk reduction and research priorities based on the results of the neighborhood assessments and other information.

VI. It shall be the ARB’s policy to work with local land-use agencies, transportation agencies, and air districts to develop ways to assess, consider, and reduce cumulative emissions, exposures, and health risks from air pollution through general plans, permitting, and other local actions.

We recognize that local agencies have a primary role in decisions affecting land use, community health, and welfare. Local land-use agencies and transportation agencies are directly responsible for the planning and siting of new air pollution sources, and local air districts also play an important role by issuing permits for new industrial sources of air pollution. As such, we are committed to working as partners with these agencies and other stakeholders to develop the technical tools and guidance necessary to consider the cumulative impacts of local sources of air pollution. The technical tools and guidance are intended to assist the local agencies in their planning and permitting actions, including the consideration of siting alternatives and air pollution mitigation measures, and shall be peer reviewed and technically valid.

We will develop these technical tools and guidance to address, as appropriate, cumulative emissions, exposures, and health risks from sources of air pollution. We will follow ARB’s existing science-based approach of evaluating public health impacts. This approach will ensure that issues are addressed from a broad, programmatic perspective and provide certainty to local agencies, the business community, and the public that decisions regarding cumulative impacts are addressed fairly and consistently. Once the technical tools and guidance are jointly developed and peer-reviewed, we will work with local agencies to best incorporate them into their existing permitting and land-use processes.

Specific actions include the following:

- Conduct joint programs with local air districts, land-use agencies (i.e., cities and counties), school districts, transportation agencies, and other
stakeholders to understand local issues and develop ways to incorporate cumulative-impacts analyses into local air district and land-use agency processes.

- Provide education and outreach to local agencies on the use of the technical tools and guidance in land-use decisions.

- Work with the local air districts to provide technical guidance to local agencies on measures that could be used to reduce or eliminate air quality impacts for specific types of sources.

- Work with the local air districts and others to maintain and compile a list of possible mitigation measures to reduce air pollution impacts for specific types of projects and the siting of sensitive receptors (e.g., schools).

- Work with Cal/EPA and the Office of Planning and Research to address environmental justice matters in city and county general plans, as required by AB 1553 (Keeley, 2001).

**VII. It shall be the ARB’s policy to support research and data collection needed to reduce cumulative emissions, exposure, and health risks, as appropriate, in all communities, especially low-income and minority communities.**

The ARB’s health research program continues to advance our ability to identify and understand air pollution’s health effects. California’s communities have a diversity of sensitive populations, and the health research program is increasing our understanding of the health effects of air pollution on those populations, including children, asthmatics, those with heart and lung disease, elderly, and other groups that may have a special sensitivity to air pollution. However, more research is needed to better characterize the variety of potential air pollution exposures within specific communities and people’s health status as it relates to air pollution.

Specific actions include the following:

- Investigate non-cancer health effects associated with acute, peak-pollutant episodes and long-term low-level exposures that may trigger increases in the incidence of respiratory problems and neurological, developmental, and reproductive disorders.

- Characterize near-source dispersion patterns for toxic air pollutants, from selected point sources, area sources, and roadways.

12/13/01
- Develop better methods to monitor community exposures through controlled scientific studies. To support this effort, develop continuous monitoring systems and miniaturized monitoring technologies.

- Identify biomarkers for air pollutants and assess individual exposures within specific communities.

- Develop geographic-based information systems for assessing health-based information within communities, and correlating that information to air pollution and socioeconomic factors.

- Conduct periodic surveys to establish a baseline and to measure progress in reducing air pollution-related health concerns, with initial emphasis in low-income and minority communities.

- Refine models to estimate cumulative emissions, exposures, and health risks at the neighborhood level, compare those risks to the risk at the regional level, and have those models peer-reviewed.

**Conclusion**

The ARB is committed to integrating environmental justice into all of its programs, policies, and regulations. We will continue to improve our outreach efforts in all California communities, ensuring that everyone has an opportunity to participate fully in the development and implementation of those programs, policies and regulations. As an oversight agency and partner with local air districts, and as an advisory agency to land-use agencies, we will work with these and other stakeholders to jointly develop the technical tools and guidance necessary to consider the cumulative air pollution impacts of local sources of air pollution. We will participate in the Cal/EPA Environmental Justice Working Group as environmental justice policies are developed for the entire agency. Even while this work is being done, we are taking steps today to reduce exposure and health risks in communities. Our goal is to ensure that all Californians, especially children and the elderly, can live, work, learn, and play in a healthful environment.
Environmental Justice Implementation Plan
for the California Department Of Pesticide Regulation
DRAFT
(March 2003)

Environmental Justice Definition: “The fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.” (Government Code Section 65040.12)

BACKGROUND

California Environmental Protection Agency Mandates
California law mandates broad responsibilities for California Environmental Protection Agency (Cal/EPA) and its boards, departments, and offices (BDOs) to incorporate environmental justice goals into their policies and programs. The law requires the formation of an interagency working group made up of the Cal/EPA Secretary, BDO chiefs, and the director of the State Office of Planning and Research (OPR). It also mandates formation of an external advisory group to the working group. These groups are to assist Cal/EPA in developing an agencywide environmental justice strategy and to provide procedural recommendations to ensure meaningful public participation in Cal/EPA activities.

Cal/EPA is specifically required by statute to do the following:

1. Conduct its programs, policies, and activities that substantially affect human health or the environment in a manner that ensures the fair treatment of people of all races, cultures, and income levels, including minority and low-income populations of the state.
2. Promote enforcement of all health and environmental statutes within its jurisdiction in a manner that ensures the fair treatment of people of all races, cultures, and income levels, including minority and low-income populations in the state.
3. Ensure greater public participation in the Agency's development, adoption, and implementation of environmental regulations and policies.
4. Improve research and data collection for programs within the agency relating to the health and environment of people of all races, cultures, and income levels, including minority and low-income populations of the state.
5. Coordinate efforts and share information with the U.S. Environmental Protection Agency.
6. Identify differential patterns of consumption of natural resources among people of different socioeconomic classifications for programs within the Agency.
7. Consult with, and review any information received from, the working group on environmental justice established to assist Cal/EPA in developing an agency-wide strategy that meets the above requirements.

Development of the Cal/EPA Environmental Justice Strategy must include the following activities, as required by Public Resources Code section 71113:

PAGE 1
1. Examine existing data and studies on environmental justice and consult with state, federal, and local agencies, and affected communities.

2. Identify and address any gaps in existing programs, policies, or activities that may impede the achievement of environmental justice.

3. Develop procedures for the coordination and implementation of intra-agency environmental justice strategies.

4. Collect, maintain, analyze, and coordinate information relating to environmental justice.

5. Develop procedures to ensure that public documents, notices, and public hearings relating to human health or the environment are concise, understandable, and readily accessible to the public. Develop guidance for determining when it is appropriate for Cal/EPA or its BDOs to translate crucial public documents, notices, and hearings relating to human health or the environment for limited English-speaking populations.

6. Make a draft available to the public and hold public meetings to receive and respond to public comment before finalizing the strategy.

**DPR Implementation**

This is an implementation plan for incorporating environmental justice principles into Department of Pesticide Regulation (DPR) programs, policies, and activities. DPR’s environmental justice policy follows Cal/EPA’s Environmental Justice Strategy.

We restate that environmental justice is the *fair treatment* and *meaningful involvement* of all people regardless of race, culture, and income with respect to the development, implementation, and enforcement of DPR regulations and policies. *Fair treatment* means that no one group of people, including race, culture, or socioeconomic, should bear a disproportionate share of negative health or environmental consequences resulting from pesticide use, or the execution of DPR programs and policies. *Meaningful involvement* means that: (1) potentially affected persons have an appropriate opportunity to participate in decisions that affect their environment and/or health; (2) the public’s contribution can influence DPR’s decision; (3) the concerns of all participants involved will be considered in the decisionmaking process; and (4) the decisionmakers seek out and facilitate the involvement of those potentially affected.
DPR Environmental Justice Plan Elements

DPR will incorporate environmental justice values and perspectives into all of our programs, policies, actions, and regulations.

Fair treatment of all people is an overarching value guiding how we do business. We will ensure that environmental justice values and perspectives inform and illuminate our standard operating practices.

Specific Actions

- Encourage DPR and county agricultural commissioner (CAC) staff to attend scheduled environmental justice training programs.
- Maintain staff awareness of the importance of environmental justice by placing a discussion of environmental justice principles and efforts to fulfill our commitment on the agenda of DPR’s managers/supervisors staff meetings, on a regular basis.
- Recognize the importance of environmental justice priorities and accomplishments by highlighting them in DPR's annual progress reports.
- Improve the use of DPR's advisory committees to solicit recommendations on how DPR can improve its programs in an equitable manner.
- Consider environmental justice when creating or modifying policies and procedures.
- Ensure that hiring practices promote a diverse work force.

DPR will integrate environmental justice considerations in developing communication to ensure meaningful public participation and promote community outreach.

DPR wants to enhance the participation of the public in state and local decisionmaking processes, and ensure that potentially affected parties are not overlooked and excluded from the process. We recognize that public participation involves two-way communications, with DPR receiving information, comments, and advice, as well as disseminating information on possible approaches, analyses, and decisions. To ensure meaningful participation, DPR will actively solicit input from communities, develop additional information on pesticides, make this information more accessible, and educate communities on the public process used to make state and local decisions. The Department recognizes the validity and importance of community knowledge, and the value of local and grassroots experiences in issues and decisions that affect them. The Department has an obligation to ensure that those affected by decisions are equal players in the decisionmaking processes. DPR recognizes the limitations on the capacity of some communities to participate in processes.

Specific Actions

- Seek out and facilitate the involvement of those primarily affected by DPR's decisions, programs, and policies, recognizing that in doing so we have made a commitment to seriously consider the input of the public.
Hold meetings in affected communities at times and in places that encourage public participation, such as evenings and weekends, at centrally located and easily accessible meeting rooms, libraries, and schools.

Ensure that affected people have the opportunity to participate in the development of policies and regulations.

Identify opportunities to enhance accessibility to information, including translating materials and documents, making documents easily accessible in the community (either by physically providing copies at central locations, and/or posting them on DPR's Web site); and providing translation services at hearings and workshops as needed. Communicate to participants how their advice was or was not utilized.

Consistent with right-to-know principles, improve access and utility of DPR data, especially pesticide use data.

DPR will conduct pesticide risk assessments in a way to consider the potential disproportionate environmental impacts on communities of color and low-income populations.

Human health and environmental research and assessment are cornerstones of informed decisionmaking to ensure a healthy environment. DPR must have a better sense of how to address issues of disproportionate impacts of pesticide use on communities. The goal is not to shift risks among populations, but to identify potential disproportionately high and adverse effects and identify alternatives that may mitigate these impacts.

Specific Actions

- Continue to conduct risk assessments taking into account sensitive populations, unique exposure scenarios, and cumulative impacts.
- Recognize that the impacts within minority populations, low-income populations, or Indian tribes may be different from impacts on the general population due to a community’s distinct cultural practices. For example, data on different patterns of living, such as subsistence fish, vegetation, or wildlife consumption and the use of well water in rural communities may be relevant to the analysis. Incorporate these considerations into the data gathering and decisionmaking processes; for example, conducting studies to assess the potential exposure of Indian plant gatherers and users to forestry herbicides.
- Mitigate unacceptable risks for all the identified races, cultures, and incomes. Develop the mitigation measures with the involvement of the affected parties. Throughout the process of public participation, DPR will elicit the views of the affected populations on measures to mitigate a disproportionately high and adverse human health or environmental effect on a low-income population, minority population, or Indian tribe, and consider community views in developing and implementing mitigation strategies.

DPR will conduct its enforcement program and work with CACs to ensure the state-county program protects all races, cultures, and incomes.

DPR will work with the CACs to ensure the state-county enforcement program protects all races, cultures, and incomes. DPR and the CACs will work vigorously to enhance pesticide use
compliance, acknowledging that this increases protections for all California citizens. DPR wants to assure that all complaints are promptly and thoroughly investigated and feedback is provided to the public on actions taken. DPR will also prioritize our enforcement resources to maximize the greatest public good.

**Specific Actions**
- Examine opportunities to improve the pesticide use permitting processes by increasing public access to the process and protection of all races, cultures, and incomes.
- Ensure enforcement investigations are conducted in a way to reduce the potential for retaliation.
- Continue to develop and distribute materials in various languages describing how citizens can file complaints, including the right to file anonymous complaints.
- Make DPR written policies and procedures on filing and investigating complaints easily accessible, including posting on the Web site.
- Continuously evaluate compliance with pesticide rules and regulations to prioritize enforcement resources.
- Evaluate uniformity of compliance actions to ensure that communities receive equal protection.
- Prepare state enforcement priorities to address areas of greatest risk.
- Improve the state and local response to pesticide incidents, in part by working with CACs to develop effective complaint-resolution processes.
- Continue to improve the accessibility of information regarding enforcement activities and actions.

DPR will continue to reduce the pesticide risks to workers.

The occupational setting poses the greatest risk of pesticide exposure. Many occupational settings involve workers of low-income and minority populations. DPR will continue to evaluate the risks to workers, ensure their unimpeded access to information, the right to file complaints without fear of retaliation, and reduce worker illnesses.

**Specific Actions**
- Improve investigation procedures to reduce the potential for retaliation.
- Continue efforts to improve physician reporting of pesticide-related illnesses.
- Work with the Department of Industrial Relations on retaliation complaints.
- Improve the access to pesticide information, especially by limited English-speaking populations.
- Periodically assess the implementation, enforcement, and effectiveness of worker safety rules and regulations, revising them as necessary to address identified problems.
- Ensure farmworker representatives have substantial input into decisions affecting their constituents.
- Periodically review DPR’s registration and evaluation policies and procedures to ensure that worker protections are actively and adequately considered. For example, deciding when to allow continued use of existing stocks of a cancelled pesticide.
Distribution of DPR's pollution prevention resources will be accessible to all races, cultures, and incomes.

Grants and other opportunities can result in changes in pest management that reduce the risks from pesticides. This is especially important in low-income and minority areas. Pest management in schools can be done in a way that poses the least risk.

Specific Actions
- Target grant programs in low-income and minority areas, particularly to assist community-based/grassroots organizations that are working on local solutions to local environmental problems.
- Facilitate the adoption of integrated pest management in schools, especially in rural and low-income areas.
- Provide informational materials in English and Spanish to the public about pesticide use and disposal.
DRAFT ENVIRONMENTAL JUSTICE POLICY

“The Department of Toxic Substances Control is committed to ensuring that all of the state’s population, without regard to color, national origin or income, are equally protected from adverse human or environmental effects as a result of the Department’s policies, programs or activities.”

The Department will:

1. Ensure that, to the extent feasible, its decisions, actions and rulemaking avoid adding to disproportionate environmental and/or health impacts on affected communities and reduce disproportionate environmental and related health impacts on such communities.

2. Promote investigation/cleanup of contaminated sites in areas with minority and low-income populations using voluntary and enforcement tools, allocating limited Orphan Site State funds in a fair manner, and prioritizing active and backlog projects in order that public health and the environment are protected.

3. Continue regional efforts to remediate brownfields so that they are returned to productive use.

4. Allocate its permitting, enforcement and clean-up resources, to the extent feasible, so as to reduce disproportionate environmental and related health impacts on ethnic minority and low-income communities.

5. Explore available mitigation measures whenever a Department decision has the potential to adversely affect any community already experiencing disproportionate environmental and/or health impacts.

6. Consider regional impacts of the Department’s decisions and activities, utilizing Geographic Information System (GIS), census and demographic data to more fully characterize areas surrounding sites and facilities, specifically indicating sensitive receptors, and other facilities and sites that may have an impact on community health.

7. Participate in area studies dealing with health, sensitive receptors, facility data, demographics or other pertinent issues to ensure that permitting and site remediation decisions within targeted communities fully incorporate environmental justice concerns; and evaluate the need to initiate permit modifications or consider modifications to remediation plans to address disparate impacts that are identified as part of the area studies.
8. Work with Cal/EPA and its boards, departments and offices, and within the Department to promote implementation of policies and procedures that ensure that low-income communities and/or communities with minority populations have access to environmental and health-related information. This will include conducting assessments to determine language and cultural needs of a specific community, providing information in appropriate languages, and encouraging early and continuous public involvement; and will include a commitment that site-related public participation documents are made available on the Department’s web site in appropriate languages.

9. Work with Cal/EPA's External Advisory Committee for Environmental Justice to develop cross-media and cross-agency approaches to community concerns.

10. Provide ongoing training for Department staff and management regarding this policy and other fundamentals of environmental justice, emphasize environmental justice is the responsibility of all programs, and ensure implementation of this policy is incorporated into performance evaluations.
To: All Departments, Boards, Commissions and Conservancies

From: Mary D. Nichols, Secretary for Resources

Re: Resources Agency Environmental Justice Policy

Enclosed you will find the Resources Agency Environmental Justice Policy. We appreciate all the feedback we received from various departments on the earlier draft that was circulated.

Each Department, Board, Commission and Conservancy is encouraged to use this policy as a template to craft a policy that better suits your needs. Our policy will be posted on the agency website. Upon the adoption of an environmental justice policy tailored to the objectives and circumstances of your organization, you are encouraged to post your policy on your website.

If you have any questions, please feel free to contact Luree Stetson at 916-654-1885.
ENVIRONMENTAL JUSTICE POLICY
California Resources Agency

Mission Statement of the California Resources Agency
To restore, protect and manage the state’s natural, historical and cultural resources for current and future generations using creative approaches and solutions based on science, collaboration and respect for all the communities and interests involved.

Environmental Justice Definition
California law defines Environmental Justice as “the fair treatment of people of all races, cultures and income with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies” (Government Code Section 65040.12 and Public Resources Code Section 72000).

Background
The concept behind the term “environmental justice” is that all people – regardless of their race, color, nation or origin or income – are able to enjoy equally high levels of environmental protection. Environmental justice communities are commonly identified as those where residents are predominantly minorities or low-income; where residents have been excluded from the environmental policy setting or decision-making process; where they are subject to a disproportionate impact from one or more environmental hazards; and where residents experience disparate implementation of environmental regulations, requirements, practices and activities in their communities. Environmental justice efforts attempt to address the inequities of environmental protection in these communities.

Agency Actions
All Departments, Boards, Commissions, Conservancies and Special Programs of the Resources Agency must consider environmental justice in their decision-making process if their actions have an impact on the environment, environmental laws, or policies. Such actions that require environmental justice consideration may include:

- Adopting regulations
- Enforcing environmental laws or regulations
- Making discretionary decisions or taking actions that affect the environment
- Providing funding for activities affecting the environment
- Interacting with the public on environmental issues

Policy
It is the policy of the Resources Agency that the fair treatment of people of all races, cultures and income shall be fully considered during the planning, decision-making, development and implementation of all Resources Agency programs, policies and activities. The intent of this policy is to ensure that the public, including minority and low-income populations, are informed of opportunities to participate in the
This CALFED Bay-Delta Program Environmental Justice Workplan (“workplan”) outlines a two-tiered approach to addressing a broad set of environmental justice issues in the context of CALFED program implementation. The first tier outlines a long-term planning process that will (1) develop environmental justice goals and objectives, (2) establish an overall environmental justice strategy for the CALFED program to achieve those goals and objectives, and (3) develop annual plans to implement that strategy. The second tier recognizes that, in the absence of the more comprehensive environmental justice strategy described above, there are still a number of critical interim actions that can and should be taken this year. Therefore, this workplan includes as an attachment (see attachment 1) the preliminary 2001 Annual Plan and outlines a process for continuing to refine that annual plan following its initial consideration by the CALFED Policy Group in December 2000. The CALFED agencies, program managers, and environmental justice stakeholders recognize that these documents are “works in progress” that have been developed with limited input and under a tight schedule. For those reasons, the documents will continue to be refined.

**Purpose Statement**

The purpose of this workplan is to outline how the CALFED agencies intend to ensure, in the context of implementation of the CALFED program, fair treatment of people of all races, cultures and incomes, such that no segment of the population bears a disproportionately high and adverse health, environmental, social or economic impact resulting from CALFED’s programs, policies or actions.

**Introduction**

On August 28, 2000, the CALFED agencies signed the Record of Decision (ROD) for the Final Programmatic EIS/EIR. Both the ROD and one of its attachments, the Implementation Memorandum of Understanding, include provisions related to the issue of environmental justice. Specifically, the ROD includes a series of “implementation commitments” that are intended to guide management of the entire CALFED program as it moves from planning to full-scale implementation during Stage 1. One of those implementation commitments states that, consistent with Federal and State authorities that require agencies to address environmental justice issues within the scope of their programs and activities, including Federal Executive Order 12898, Title VI of the Civil Rights Act and recent state legislation, the CALFED agencies are committed to addressing environmental justice challenges related to water management in the Bay-Delta watershed.

The ROD acknowledges the importance of examining the potential effects of water management reforms on rural communities and the public health and financial impacts of ecosystem and water quality program actions on the large numbers of minorities and disadvantaged people living in...
urban areas. With that understanding, the CALFED Program and agencies are committed to seeking fair treatment of people of all races, cultures, and incomes, such that no segment of the population bears a disproportionately high and adverse health, environmental, social or economic impact resulting from CALFED’s programs, policies, or actions. The Implementation Memorandum of Understanding reiterates these same commitments in the form of an “implementation principle.”

In order to turn these commitments and principles into action, the ROD requires the CALFED agencies, by the end of 2000, to collaborate with environmental justice and community stakeholders to develop a comprehensive environmental justice workplan across all program areas. This workplan was intended to ensure that the CALFED agencies developed the capacity and process to understand, monitor, and address environmental justice issues as the program moves into implementation, including identifying and developing specific methods to address and mitigate environmental justice impacts.

In addition to the commitment to develop an environmental justice workplan, the ROD includes a broader set of provisions that address concerns related to environmental justice and implementation of the CALFED Program (see attachment 2).

Background

The basic concept behind the term “environmental justice” is that all people – regardless of their race, color, nation of origin, or income – are able to enjoy equally high levels of environmental protection. Environmental justice communities are commonly identified as those where residents are predominantly minorities or low-income; where residents have been excluded from the environmental policy setting or decision-making process; where they are subject to a disproportionate impact from one or more environmental hazards; and where residents experience disparate implementation of environmental regulations, requirements, practices and activities in their communities. Environmental justice efforts attempt to address the inequities of environmental protection in these communities. Legal authorities to support these efforts include both statutory and common law protections. Both the Federal government and the State of California have taken formal steps in recent years to address this issue.

An important milestone in the Federal government’s environmental justice actions occurred in 1994 when President Clinton signed Executive Order 12898 to establish environmental justice as a national priority (see attachment 3). The Order states that “each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations.” In addition, the Order directs all Federal agencies to develop, by March 1995, an Environmental Justice Strategy that identifies and addresses any disproportionately high and adverse effects of their programs, policies, and activities. The Order includes several additional specific provisions related to human health data collection, impact analysis in environmental documentation, and subsistence
consumption of fish and wildlife. All Federal agencies are also required under the Order to ensure that all of their programs and activities receiving federal funding comply with Title VI of the 1964 Civil Rights Act. Title VI bans discrimination on the basis of race, color, or national origin in federally-funded projects and decisions. Implementation of this workplan will help to ensure that, in the context of the CALFED program and its proposed actions, the Federal agencies are in compliance with the Executive Order.

Similarly, the State of California’s laws include explicit provisions related to the issue of environmental justice. Existing laws (Public Resources Code Section 72000 and Government Code Section 65040.12) establish the Office of Planning and Research as the coordinating agency in state government for environmental justice programs and defines environmental justice to mean “the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws and policies.” In addition, the Governor recently signed two pieces of legislation – Senate Bill 115 (Solis) and Senate Bill 89 (Escutia) – that amend existing statutes and expand the State’s environmental justice responsibilities. The new laws require California’s Secretary for Environmental Protection, by January 2002, to convene an interagency Working Group on Environmental Justice to develop and begin implementation of an interagency environmental justice strategy and to develop a model mission statement for the California Environmental Protection Agency. In addition to a broader set of requirements, the laws also call for the creation of a multi-stakeholder advisory committee by January 2002 to assist the working group in its efforts (see attachment 4). Implementation of this workplan will help to ensure that, in the context of the CALFED program and its proposed actions, the State agencies are in compliance with the provisions of state law.

Under California law, water resources and some associated ecological resources are held in trust for the public by the State. The public trust doctrine originated in common law and has been expanded by State courts to apply to certain recognized public uses and values. The State has the obligation to protect these resources where feasible for all citizens of California. Thus, the basic principle of the public trust doctrine, that water resources are held in trust for all citizens, supports the main tenant of environmental justice, that no persons or communities should be disproportionately affected by the use or protection of those resources.

Tier One – Long-Term Planning Process

As noted above, this section outlines a long-term planning process that will develop environmental justice goals and objectives, establish an overall environmental justice strategy for the CALFED program to achieve those goals and objectives, and develop annual plans to implement that strategy.

A. Development of Goals and Objectives

• Under this task, environmental justice goals and objectives will be established for the CALFED Bay-Delta program. These goals would likely reflect provisions of the Federal Executive Order, State law, existing Federal agency environmental justice
strategies, the CALFED mission statement and/or CALFED solution principles by applying the principles of environmental justice to the existing goals and objectives of the CALFED Program. It is envisioned that both an overarching set of goals and objectives, outlining how the CALFED Program will address environmental justice and meet its state and federal requirements, and specific goals and objectives for each program area will be developed, as appropriate.

- By the end of February 2001, the CALFED Environmental Justice Coordinator will work with the new broad public advisory committee to convene an Environmental Justice Workgroup that will operate as a public advisory group. Specifically, the new broad public advisory committee will collaborate with the Environmental Justice Steering Committee, the broader Environmental Justice Coalition, CALFED program managers, the agencies, and other community stakeholders throughout the state to ensure the inclusion of an appropriate and geographically diverse set of qualified participants. The appropriate size of the group, qualifications for membership, and organizational protocols will be established by the broad public advisory committee, working with the Coordinator. In doing so, the National Environmental Justice Advisory Committee (NEJAC) will be considered as a model.

- By the end of April 2001, the Environmental Justice Coordinator and the Environmental Justice Workgroup, in coordination with the CALFED agencies and program managers, will convene a series of regional workshops (geographically dispersed across the state) to hold discussions and gain input on environmental justice issues related to CALFED implementation (e.g., an appropriate and comprehensive set of environmental justice goals and objectives, an overall long-term strategy) and to generally enhance outreach and education on the CALFED program for minority and low-income communities.

- By the end of May 2001, appropriate meetings of the Environmental Justice Workgroup will be initiated to develop a set of environmental justice goals and objectives for the CALFED program. These goals and objectives will be developed based largely on input from the regional workshops and will involve the participation of the CALFED agencies and program staff. By the end of June, a set of goals and objectives will be finalized by the CALFED Program.

- By the end of July 2001, the goals and objectives will be formally reviewed by and submitted for approval to the CALFED Management Team and the Bay Delta Advisory Committee (or its successor) and adopted by the CALFED Policy Group (or its successor).
B. Development of an overall CALFED Environmental Justice Strategy

• Under this task, a CALFED Environmental Justice Strategy will be developed to ensure that the goals and objectives will be achieved. This strategy represents a broad description of the activities and mechanisms that CALFED must develop and institutionalize to ensure implementation of the goals and objectives. The specific tasks themselves will be detailed in the annual plans described below. Much of this effort will be accomplished concurrently with the process outlined above.

• Specifically, by the end of March 2001, the Environmental Justice Coordinator will initiate a series of planning meetings with the Environmental Justice Workgroup (or some subgroup) to begin review of existing environmental justice strategies and to outline the necessary components of a CALFED strategy.

• The regional workshops, to be convened by the end of April 2001, will involve the active participation of the Environmental Justice Workgroup and will allow the workgroup to gain input on appropriate provisions of a CALFED environmental justice strategy. Members of the workgroup representing community-based organizations will serve as key liaisons in their respective regions.

• By the end of June 2001, after meetings have been held to develop an appropriate set of goals and objectives, meetings of the Environmental Justice Workgroup (or some subgroup) will be initiated to develop the broad long-term environmental justice strategy for the CALFED program. If plausible, an attempt will be made to do this concurrently with the development of the goals and objectives described above.

• During this process, the Environmental Justice Coordinator will initiate meetings between the Environmental Justice Workgroup, related program-specific advisory or workgroups (e.g., Watershed Workgroup, Delta Drinking Water Council, Water Use Efficiency Public Advisory Committee), and the CALFED Science Program to (1) ensure consistency between the evolving environmental justice strategy and individual program plans and (2) develop appropriate measures of success for each program area to determine whether the strategy is effectively achieving environmental justice goals and objectives. The Environmental Justice Strategy will be finalized by the CALFED Program by the end of August 2001.

• By the end of September 2001, the Environmental Justice Strategy will be formally reviewed by and submitted for approval to the CALFED Management Team and the Bay Delta Advisory Committee (or its successor). The CALFED Policy Group (or its successor) will review and adopt the strategy by the end of October 2001, prior to submission of the CALFED Annual Report to Congress and the Legislature.
C. Development of Annual Plans

- Under this task, the CALFED Program and agencies will develop each year an Annual Plan to implement the CALFED Environmental Justice Strategy.

- By the end of February each year, the Environmental Justice Coordinator will facilitate program-specific meetings between the Environmental Justice Workgroup and CALFED program managers (e.g., storage, ecosystem restoration), advisory groups, workgroups and the CALFED Science Program to (1) review the previous year’s workplan, (2) consider and evaluate its effectiveness in achieving goals and objectives in each program area, (3) adaptively manage the workplan to make appropriate adjustments in actions for the next Annual Plan to ensure that goals and objectives are achieved. All such Workgroup meetings will provide an opportunity for public comment. As much as possible, this annual plan development process should move forward with and rely on the program managers’ existing efforts to develop annual operating/implementation plans for their particular program.

- By the end of May each year, the Environmental Justice Coordinator, the Environmental Justice Workgroup and CALFED program managers will develop a draft Annual Plan that identifies specific actions and milestones for the next calendar year and outlines program funding and costs, processes for ensuring participation of affected communities, and steps to incrementally evaluate and achieve measures of success. These same measures should be included, as appropriate, in the program managers’ annual operating/implementation plans for their particular program.

- By the end of June each year, one or more open public meeting(s) of the Environmental Justice Workgroup will be convened (potentially in geographically diverse locations) to gain input on the draft Annual Plan. As necessary, the Environmental Justice Workgroup will assist the CALFED Program in revising and finalizing the draft plan based on input from the meeting(s).

- By the end of August each year, the Annual Plan will be formally reviewed by and submitted for approval to the CALFED Management Team and the Bay Delta Advisory Committee (or its successor). The CALFED Policy Group (or its successor) will review and adopt the strategy by the end of September each year, prior to submission of the CALFED Annual Report to Congress and the Legislature.

Tier Two – 2001 Annual Workplan Process

While Section C above outlines the general process to guide development of annual plans, that process will likely be most useful in developing the plan for 2002 and subsequent years. Nevertheless, in the absence of a comprehensive set of goals and objectives and an overall Environmental Justice Strategy at this time, there are still a number of specific interim actions that
need to be taken in the near-term (i.e., before the process outlined above could be completed in 2001) to ensure that environmental justice issues are adequately considered and integrated in CALFED implementation.

In order to get some activity underway this year, the attached “Preliminary 2001 Environmental Justice Annual Plan” has been developed quickly with limited input from the CALFED agencies, program managers, and representatives of the Environmental Justice Steering Committee. Although this plan will be refined before the end of February by the Environmental Justice Coordinator, in collaboration with the participants listed above, it also identifies a series of critical issues and actions that need to be addressed and implemented in the early months of CALFED implementation and a process for accomplishing them. Specifically, the preliminary plan includes actions and processes to ensure:

- effective strategies for public participation (including workgroups and workshops)
- inclusion of environmental justice criteria in all upcoming project solicitation proposals
- adequate consideration of social and economic impacts in environmental documentation
- environmental justice training and education for agency and program staff
- collection and analysis of new demographic information and data
- adequate staffing and financial resources (including capacity building)
- compliance with all relevant Federal and State orders and statutes

Specific tasks, timelines and responsibilities for implementing these efforts in the context of 2001 implementation are included in the attached Preliminary Annual Plan.
CONSIDER THE ADOPTION OF A POLICY STATEMENT RELATING TO ENVIRONMENTAL JUSTICE

PARTY:
California State Lands Commission

BACKGROUND:
At its last meeting, the Commission requested staff to prepare an environmental justice policy to ensure the integration of environmental justice issues into decisions by the Commission and staff. Environmental justice is defined under State law as “the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.”

Environmental justice laws and policies developed in the mid-1990s at the federal level in response to siting industrial facilities such as toxic waste dumps that pose a significant risk to human health in minority and low-income communities. State and local governments across the nation have also begun to incorporate environmental justice issues into their planning and decision-making. Federal policy specifically requires federal agencies to address the issue of disproportionate impacts to minority and low-income communities. While similar proposed requirements have been introduced in the legislature, to date, California law only requires that existing law be implemented fairly.

Commission staff has become more familiar with environmental justice issues by, among other efforts, attending forums hosted by the Governor’s Office of Planning and Research, the overall coordinator for environmental justice programs in State government. Although the State Lands Commission is not currently required by State law to develop an environmental justice policy, the Commission’s express interest coincides with the development of policies by other State agencies. In recognition of the intent of environmental justice, staff recommends adoption and implementation of the attached policy statement.

Full integration of environmental justice issues into State Lands Commission decision-making will be a lengthy process and must reflect public participation and collaboration.
As an example, the California Air Resources Board approved an environmental justice policy last December that took nearly two years to develop with the help of environmental and community groups, industry representatives, and government.

Therefore, it is also recommended that the Commission direct staff to develop a specific plan for public participation and collaboration on a more detailed environmental justice policy and to provide its plan and recommendations to the commission in six months. Staff will collaborate with representatives of minority groups and the Office of Planning and Research to formulate this plan.

EXHIBIT

A. Environmental Justice Policy Statement

RECOMMENDATIONS

IT IS RECOMMENDED THAT THE COMMISSION:

1. ADOPT THE GUIDANCE POLICY STATEMENT ON ENVIRONMENTAL JUSTICE ATTACHED AS EXHIBIT A.

2. DIRECT STAFF TO IMPLEMENT THIS POLICY.

3. DIRECT STAFF TO DEVELOP A SPECIFIC PLAN FOR PUBLIC PARTICIPATION AND COLLABORATION ON A MORE DETAILED ENVIRONMENTAL JUSTICE POLICY AND TO PROVIDE ITS PLAN AND RECOMMENDATIONS TO THE COMMISSION IN SIX MONTHS.
Exhibit A

Environmental Justice Policy Statement
California State Lands Commission

Mission Statement: The California State Lands Commission serves the people of California by providing stewardship of the lands, waterways, and resources entrusted to its care through economic development, protection, preservation, and restoration.

Commission Jurisdiction/Programs

The California State Lands Commission (Commission) holds title to and manages four million acres of tide and submerged land underlying the State’s navigable and tidal waterways. These lands are held under and governed by the provisions of the Public Trust for specific public purposes such as fishing, water dependent commerce and navigation, ecological preservation, and scientific study, among others.

The Commission also holds title to and manages about 570,000 acres of State School Lands. The school lands are held in trust for the betterment of the common schools of the State and the revenue, by statute, goes to support the State Teachers Retirement System. The school lands must be administered for the benefit of the public.

The Commission grants leases and permits on State lands for such purposes as marinas, industrial wharves, tanker anchorages, timber harvesting, dredging, grazing, mining, oil and gas, and geothermal development. The Commission has regulatory authority over all marine oil facilities and terminals in the State.

The Commission also administers programs to remove hazardous artificial structures from waterways that pose a risk to public health and safety and participates in projects and programs to preserve, enhance, and restore natural resources.

In the performance of its duties, the Commission frequently makes land use and permitting decisions, produces regulations, and takes other discretionary actions that may have an impact on the environment and human health.

Environmental Justice Policy

The Commission pledges to conduct its business with environmental justice as an essential consideration. Environmental justice is defined by State law as “the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.”

The Commission stresses fair treatment of all members of the public in its everyday activities, decision-making, and regulatory affairs. The Commission has earned a reputation for unbiased and balanced decisions concerning uses of public lands and resources. The Commission
reaffirms its commitment to an informed and open process in which all people are treated equitably and with dignity and in which its decisions are tempered by environmental justice considerations. The Commission will communicate this policy to the cities, counties, and harbor districts who manage lands granted to them by the Commission and for which it retains oversight.

The Commission pledges to work toward the incorporation of environmental justice into its processes by:

1. Identifying areas of relevant populations that might be adversely affected by Commission programs or by projects submitted by outside parties for its consideration.

2. Seeking out community groups and leaders to encourage communication and collaboration with the Commission and its staff.

3. Distributing public information as broadly as possible in multiple languages, as needed, to encourage participation in the Commission’s public processes.

4. Incorporating consultations with affected community groups and leaders while preparing environmental analyses of projects submitted to the Commission for its consideration.

5. Ensuring that public documents and notices relating to human health or environmental issues are concise, understandable, and readily accessible to the public, in multiple languages, as appropriate.

6. Holding public meetings, public hearings, and public workshops at times and in locations that encourage meaningful public involvement by members of the affected communities.

7. Educating present and future generations in all walks of life about public access to lands and resources managed by the Commission.

8. Ensuring that all reasonable alternatives are considered when siting facilities that may be near relevant populations.

9. Providing appropriate training on environmental justice issues to its staff so that consideration of such issues is incorporated into its daily activities.

10. Reporting periodically to the Commission on how environmental justice has been incorporated into programs and activities conducted by the Commission.

This policy shall be reviewed annually to evaluate its effectiveness in achieving environmental justice in the Commission’s management of the lands and resources within its jurisdiction.
**Director's Policy**

**Title:** Environmental Justice

**Policy**

The Department of Transportation (Department) incorporates Environmental Justice into its programs, policies, and activities to ensure there are no disproportionate adverse impacts, particularly on minority and low-income populations. The Department emphasizes the fair treatment and meaningful involvement of people of all races, cultures, and income levels, including minority and low-income populations, from the early stages of transportation planning and investment decision-making through construction, operations, and maintenance.

The Department’s mission is to improve mobility across California; this includes providing transportation services in an equitable manner to all segments of society. The Department strives for equity and balance in transportation investments, economic prosperity, and environmental protection.

**Intended Results**

The intent of this policy is to ensure that the public, including minority and low-income populations, are not discriminated against, treated unfairly, or made to suffer disproportionately from transportation decisions. This policy directs the Department to encourage the public to express its needs and concerns so that transportation decisions better reflect community values and interests.

**Responsibilities**

**Department Management:** Supports this policy and its implementation.

**Deputy Directors for Civil Rights, Planning and Modal Programs... and Project Delivery:** Develop overall departmental guidance, develop policies and programs in statewide planning and develop procedures for project delivery, respectively. They coordinate their efforts to successfully promote and implement Environmental Justice.
Director's Policy
Number 21
Page 2

Managers and Supervisors:
- Exemplify and actively support Environmental Justice.
- Ensure that their subordinates understand and comply with departmental policies regarding Environmental Justice.
- Establish a positive climate in their work unit, including mechanisms and procedures, to eliminate or reduce any obstacles to achieving Environmental Justice.

Employees:
- Support and implement this policy in performing their jobs.
- Ensure that the public, including minority and low-income populations, have a fair opportunity to express their needs and concerns in planning and transportation investment decisions.
- Set a positive example of public service and concern for the communities they serve by following the principles of Environmental Justice in their work.

APPLICABILITY

All who work for the Department in any capacity.

JEFF MORALES
Director

Date Signed
DEPUTY DIRECTIVE

Number: DM-63

Refer to
Director's Policy: 21 - Environmental Justice

Effective Date: 11-06-01

Supersedes: New

TITLE
Environmental Justice and Civil Rights in Transportation Decision-Making

POLICY

The Department of Transportation (Department) will:

- Avoid, minimize, or mitigate any disproportionate adverse impacts of plans and projects on minority and/or low-income populations.
- Provide equitable transportation services to the public, including minority and low-income populations.
- Strive for a balance of transportation investments, economic prosperity, and environmental protection.
- Include the public, including minority and low-income populations, in transportation investment decision-making from the early planning stages through construction, operations and maintenance.

DEFINITION/BACKGROUND

"Environmental Justice" is defined in California law as "the fair treatment of people of all races, cultures and income with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies" (Government Code Section 65040.12 and Public Resources Code Section 72000).

In federal law, the principles behind Environmental Justice can be traced to Title VI of the Civil Rights Act of 1964, Presidential Executive Orders 12898 and 13146 (Environmental Justice and Limited English Proficiency, respectively), the National Environmental Policy Act of 1969, Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, the Transportation Equity Act for the 21st Century, and other laws concerning nondiscrimination, equitable treatment, and environmental protection.
The intent of Environmental Justice is to address the potential impact of plans and projects on communities by having agencies fully consider these impacts from the early planning stages through construction, operation, and maintenance.

It is the long-standing policy of the Department to ensure that transportation plans and programs are consistent with the requirements of Title VI of the Civil Rights Act of 1964 and related statutes that prohibit discrimination.

**RESPONSIBILITIES**

Deputy Directors, District Directors, Division Chiefs, and Program Managers:
- Promote awareness of Environmental Justice.
- Ensure that departmental policies, procedures, programs, products, and services are consistent with federal and State laws, regulations, and requirements and reflect the principles of Environmental Justice, Title VI, and related nondiscrimination requirements.
- Provide appropriate resources, time, and training to deliver products and services consistent with this Deputy Directive.

Deputy Director, Civil Rights:
- Provides guidance for developing policies and programs to promote and implement Environmental Justice in the Department.
- Reviews, enforces, and certifies departmental, Business, Transportation, and Housing Agency, and any other third-party programs for compliance with Environmental Justice, Title VI, and related nondiscrimination requirements.

Deputy Director, Planning and Modal Programs:
- Oversees the development of Environmental Justice policies and assistance programs related to transportation planning; mass transportation, aeronautics, rail programs, local assistance; and transportation system information.
• Ensures that transportation and planning processes and products comply with Title VI, Environmental Justice, and related nondiscrimination requirements.

Chief Engineer (Deputy Director, Project Delivery): Ensures that procedures and processes for project delivery reflect the principles of Environmental Justice, Title VI, and related nondiscrimination requirements.

Deputy Director, Maintenance and Operations: Ensures that processes and services related to the maintenance and operation of State transportation facilities reflect the principles of Environmental Justice, Title VI, and related nondiscrimination requirements.

Chief, Division of Transportation Planning:
• Develops policies and programs to implement Environmental Justice in statewide planning.
• Develops strategies to improve the participation of underrepresented groups in transportation investment decision-making.
• Provides analysis, technical assistance, and training to address and promote Environmental Justice.

Chief, Division of Environmental Analysis:
• During project development, ensures compliance with Environmental Justice principles, Title VI, and related nondiscrimination requirements under the National Environmental Policy Act.
• Conducts project level and community impact assessments concerning adverse environmental, economic, health, and social issues.
• Provides to those involved with environmental analysis guidance and training on ways to understand, measure, avoid, or minimize adverse project impacts on the human environment.

Deputy District Directors, Planning and Environmental Planning: Work with local, regional, and transit planning agencies to coordinate efforts and information for addressing Environmental Justice issues.
Deputy Director
Number DU-63
Page 1

Employees: Understand and comply with departmental policy and federal and State laws and regulations when making decisions and arrangements regarding transportation and Environmental Justice

APPLICABILITY

All who work for the Department in any capacity.

Tony V. Harris
Chief Deputy Director

11/05/2001
Date Signed
ENDNOTES

2 The National Environmental Justice Training Collaborative was formed by the US Environmental Protection Agency, Office of Environmental Justice in 2000. The Collaborative’s goal was to develop EJ workshops and train instructors to deliver these workshops with the assistance of Maresh Brains at Work, consultants.
3 State Lands Commission Calendar Item 71, Exhibit A, 10/01/02.
4 California Government Code § 65041.
General Plan Guidelines Chapter 2: Sustainable Development and Environmental Justice

By Governor’s Office of Planning and Research
CHAPTER 2

Sustainable Development and Environmental Justice

All statutory references are to the California Government Code unless otherwise noted.

This chapter addresses the incorporation of environmental justice into the general plan. While environmental justice is not a mandatory topic in the general plan, there is a strong case for its inclusion. Federal and state anti-discrimination statutes, which have a long history, apply to planning as they do to other policy areas. As discussed below, environmental justice issues are often related to failures in land use planning. Planning policies that promote livable communities and smart growth can be tools for achieving environmental justice. In keeping with that idea, this chapter begins with a discussion of sustainable development. Sustainable development provides a context for understanding how environmental justice fits into land use planning. This chapter concludes with a discussion of transit-oriented development, which has important implications for environmental justice and sustainable development.

SUSTAINABLE DEVELOPMENT

Sustainable development encompasses established principles of good planning and advocates a proactive approach to future development. The basic concept of sustainability is meeting the needs of current generations without compromising the ability of future generations to meet their own needs. Sustainable development can be further defined as promoting the “three E’s”: environment, economy, and equity. For example, a decision or action aimed at promoting economic development should not result in decreased environmental quality or social inequity. Ensuring that a given decision or action promotes all three E’s is often referred to as the triple bottom line.

What does sustainable development look like on the ground? In a community that is developing sustainably, the neighborhood is the basic building block of urban design and is characterized by walkability, mixed-use development, and mixed-income housing. Walkability is a function of compactness and density. Attention to streetscape and public spaces is a key design element in creating desirable places to live. Such neighborhoods, also known as neo-traditional or new urbanist development, are more likely to support efficient transit systems. The character and function of each neighborhood is then placed properly within its regional setting. This approach to planning, from the neighborhood to the regional level, is often referred to as smart growth.

Sustainable development goals and policies include the following:

♦ Decrease urban sprawl.
  ➢ Promote compact, walkable, mixed-use development.
  ➢ Promote infill development.
  ➢ Restore urban and town centers.
  ➢ Limit non-contiguous (leaffrog) development.
  ➢ Promote transit-oriented development.

♦ Protect open space and working landscapes.
  ➢ Conserve prime agricultural lands.
  ➢ Conserve lands of scenic and recreational value.
  ➢ Use open space to define urban communities.

♦ Protect environmentally sensitive lands.
  ➢ Conserve natural habitat lands.
  ➢ Preserve habitat connectivity.
  ➢ Minimize impact to watershed functions, including water quality and natural floodways.
  ➢ Avoid natural hazards.

♦ Create strong local and regional economies.
  ➢ Encourage jobs/housing balance.
  ➢ Provide adequate housing for all income levels.
  ➢ Encourage the expansion of telecommunications infrastructure.
  ➢ Provide a fair and predictable land use planning process.

♦ Promote energy and resource efficiency.
  ➢ Support energy- and resource-efficient industries.
  ➢ Promote waste reduction programs, such as recycling.
Chapter 2: Sustainable Development and Environmental Justice

- Promote alternative forms of transportation.
- Promote energy- and resource-efficient buildings.

- Promote equitable development.
  - Require fair treatment in the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.
  - Promote mixed-income housing development.
  - Promote alternative transportation options to increase access.
  - Promote economic opportunity for all segments of the community.
  - Protect culturally significant sites.

The comprehensive, integrated, and long-term nature of the general plan makes it an ideal vehicle for implementing local sustainable development goals. When preparing or amending a general plan, sustainable development policies or programs may be addressed within the various elements of the plan. For example, policies on minimizing urban sprawl may be addressed in the land use element; policies for prime agricultural land preservation may be introduced in the open-space element; and the transportation element may be used to address public transportation concerns.

The principles of sustainable development may also guide the overall goals of the general plan. For example, Santa Clara County’s general plan addresses four themes of sustainable development in its general plan vision: social and economic well-being, managed and balanced growth, livable communities, and responsible resource conservation. The general plan’s goals for social and economic well-being include achieving “a healthy, diverse economy and adequate employment opportunities” by reaching “sustainable levels of growth and job formation consistent with planned improvements in housing, transportation, urban services, and maintenance of environmental quality.” Goals for the other themes also reflect the necessary balance of social, environmental, and economic objectives that characterizes sustainable development.

General plans can work in concert with other plans and policy documents to promote sustainability. For instance, the City of Pasadena uses a quality-of-life index to identify, measure, and set quality-of-life indicators for a healthier, more sustainable city. “The Quality of Life in Pasadena” index combines information from the city’s general plan and other documents and addresses such topics as the environment, health, education, transportation, the economy, and employment. The City of Oakland includes in each staff report to the City Council a discussion of how the proposed action would promote the three E’s of sustainability. The concept and application of sustainable development is evolving through creative interpretation and use.

Jobs/Housing Balance

One issue that cuts across several elements of the general plan is jobs/housing balance. Jobs/housing balance compares the available housing and available jobs within a community, a city or other geographically defined subregion. Relying on the automobile as our primary means of transportation has encouraged patterns of development and employment that are often inefficient. Suburbanites routinely commute 25 miles or more from their homes to their places of employment. Public transit is impractical for most people because jobs are dispersed throughout employment regions and housing density is too low. With residential and commercial land uses often separated by long distances, people must make multiple car trips to perform routine errands, such as grocery shopping, going to the bank, eating out, going to the dentist, etc.

Jobs/housing balance is based on the premise that commuting, the overall number of vehicle trips, and the resultant vehicle miles traveled can be reduced when sufficient jobs are available locally to balance the employment demands of the community and when commercial services are convenient to residential areas. Planning for a jobs/housing balance requires in-depth analyses of employment potential (existing and projected), housing demand (by income level and housing type), new housing production, and the relationship between employment opportunities and housing availability. Other factors, such as housing costs and transportation systems, must also be evaluated.

Improving the jobs/housing balance requires carefully planning for the location, intensity, and nature of jobs and housing in order to encourage a reduction in vehicle trips and miles traveled and a corresponding increase in the use of mass transit and alternative transportation methods, such as bicycles, carpools, and walking. Strategies include locating higher-density housing near employment centers, promoting infill development, promoting transit-oriented development, actively recruiting businesses that will utilize the local workforce, developing a robust telecommunications infrastructure, developing workforce skills consistent with evolving local economies, and providing affordable housing opportunities within the community. Jobs-housing provisions most directly affect the design of mixed-use, walkable neighborhoods. Planning for a...
Environmental Justice

Environmental justice is defined in state planning law as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies (§65040.12(e)). The Governor’s Office of Planning and Research (OPR) is required to provide guidance to cities and counties for integrating environmental justice into their general plans (§65040.12(c)). This section discusses the framework for environmental justice and the relationship of environmental justice to the general plan. The recommendations in this chapter are also reflected in the chapters on the required general plan elements (Chapter 4), optional elements (Chapter 6), and public participation (Chapter 8).

Federal Framework

The basis for environmental justice lies in the Equal Protection Clause of the U.S. Constitution. The Fourteenth Amendment expressly provides that the states may not “deny to any person within [their] jurisdiction the equal protection of the laws” (U.S. Constitution, amend. XIV, §1).

On February 11, 1994, President Clinton signed Executive Order (E.O.) 12898, titled “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.” The executive order followed a 1992 report by the U.S. Environmental Protection Agency (U.S. EPA) indicating that “[r]acial minority and low-income populations experience higher than average exposures to selected air pollutants, hazardous waste facilities, and other forms of environmental pollution.” Among other things, E.O. 12898 directed federal agencies to incorporate environmental justice into their missions.

In a memorandum accompanying E.O. 12898, President Clinton underscored existing federal laws that can be used to further environment justice. These laws include Title VI of the Civil Rights Act of 1964 and the National Environmental Policy Act (NEPA), among others. Title VI prohibits any recipient (state or local entity or public or private agency) of federal financial assistance from discriminating on the basis of race, color, or national origin in its programs or activities (42 USC §2000d-§2000d-7). State and local agencies that receive federal funding must comply with Title VI. Pursuant to the Civil Rights Restoration Act of 1987, this requirement applies to all agency programs and activities, not just those that receive direct federal funding. In response, many state and local agencies that receive federal funding have initiated environmental justice programs of their own.

NEPA applies to projects carried out or funded by a federal agency (including the issuance of federal permits). NEPA is useful relative to environmental justice because it requires public participation and discussion of alternatives and mitigation measures that could reduce disproportionate effects on low-income and minority populations. On December 10, 1997, the Council on Environmental Quality (CEQ) released NEPA Guidance for Federal Agencies on Key Terms in E.O. 12898. This document is a useful reference for planners, although it is focused on environmental review of individual projects rather than long-term comprehensive land use planning.

State Framework

Anti-discrimination laws existed in California prior to the passage of the first state environmental justice legislation in 1999. The California Constitution prohibits discrimination in the operation of public employment, public education, or public contracting (Article I, §31). State law further prohibits discrimination under any program or activity that is funded or administered by the state (§11135). The Planning and Zoning Law prohibits any local entity from denying any individual or group of the enjoyment of residence, land ownership, tenancy, or any other land use in California due to the race, sex, color, religion, ethnicity, national origin, ancestry, lawful occupation, or age of the individual or group of individuals (§65008). The Fair Employment and Housing Act (FEHA) specifically prohibits housing discrimination on the basis of race, color, religion, sex, sexual orientation, marital status, national origin, ancestry, familial status, disability, or source of income ($12900, et seq.)

In 1999, Governor Davis signed SB 115 (Solis, Chapter 690, Statutes of 1999) into law, defining environmental justice in statute and establishing OPR as
the coordinating agency for state environmental justice programs (§65040.12). SB 115 further required the California Environmental Protection Agency (Cal/EPA) to develop a model environmental justice mission statement for boards, departments, and offices within the agency by January 1, 2001 (Public Resources Code §72000-72001).

In 2000, Governor Davis signed SB 89 (Escutia, Chapter 728, Statutes of 2000), which complemented SB 115 by requiring the creation of an environmental justice working group and an advisory group to assist Cal/EPA in developing an intra-agency environmental justice strategy (Public Resources Code §72002-72003). SB 828 (Alarcón, Chapter 765, Statutes of 2001) added and modified due dates for the development of Cal/EPA’s intra-agency environmental justice strategy and required each board, department, and office within Cal/EPA to identify and address any gaps in its existing programs, policies, and activities that may impede environmental justice no later than January 1, 2004 (Public Resources Code §71114-71115).

AB 1553 (Keeley, Chapter 762, Statutes of 2001) required OPR to incorporate environmental justice considerations in the General Plan Guidelines. AB 1553 specified that the guidelines should propose methods for local governments to address the following:

♦ Planning for the equitable distribution of new public facilities and services that increase and enhance community quality of life.
♦ Providing for the location of industrial facilities and uses that pose a significant hazard to human health and safety in a manner that seeks to avoid overconcentrating these uses in proximity to schools or residential dwellings.
♦ Providing for the location of new schools and residential dwellings in a manner that avoids proximity to industrial facilities and uses that pose a significant hazard to human health and safety.
♦ Promoting more livable communities by expanding opportunities for transit-oriented development.

♦ “Stacking” commissions or committees with certain interests while ignoring the interests of other segments of the community, such as minority and low-income residents.
♦ Holding meetings at times or in locations that minimize the ability of certain groups or individuals to participate.
♦ Using English-only written or verbal communication when a non-English speaking population will be affected by a planning decision.
♦ Requiring lower levels of mitigation for projects affecting low-income or minority populations.
♦ Unevenly enforcing environmental rules.

Geographic inequity describes a situation in which the burdens of undesirable land uses are concentrated in certain neighborhoods while the benefits are received elsewhere. It also describes a situation in which public amenities are concentrated only in certain areas. Examples of geographic inequity include situations in which:

♦ Certain neighborhoods have a disproportionate share of industrial facilities that handle or produce hazardous waste, while the economic benefits are distributed to other neighborhoods (in the form of jobs and tax revenue).
♦ Certain neighborhoods have a disproportionate share of waste disposal facilities, while the benefits of such facilities are received by the community or region as a whole.
♦ Certain neighborhoods have ample community centers, parks, and open space and thus experience more of the environmental benefits associated with these amenities, while other neighborhoods have fewer such amenities.

Public Participation

Community involvement in the planning process is an important part of environmental justice. Cities and counties should develop public participation strategies that allow for early and meaningful community involvement in the general plan process by all affected population groups. Participation plans should incorporate strategies to overcome linguistic, institutional, cultural, economic, and historic barriers to effective participation. Chapter 8 is dedicated to the issue of public participation and suggests methods to improve outreach to and communication with all population groups, including low-income and minority populations.
Compatibility

At the general plan level, discussions about environmental justice involve a central land use concept: compatibility. The primary purpose of planning, and the source of government authority to engage in planning, is to protect the public health, safety, and welfare. Incompatible land uses may create health, safety, and welfare issues for the community. Geographic inequity occurs when incompatible land uses disproportionately affect a particular socioeconomic segment of the community. In this sense, environmental justice problems indicate a failure of land use planning to deliver on its original promise—reducing the harmful effects of incompatible land uses.

Traditionally, zoning has attempted to minimize health and safety risks by segregating land uses. However, taking this approach too far has negative consequences that run counter to the goals of sustainable development. Rigid separation of land uses has resulted in disconnected islands of activity and contributed to sprawl. As discussed above, development patterns characterized by single-use zoning result in the automobile being the only viable transportation option, which has high environmental, economic, and social costs.

The traditional pyramidal zoning model places single-family homes at the pinnacle, followed by denser multi-family housing, followed by office and commercial uses, and, finally, followed by industrial uses at the base. In this model, land uses at a lower level on the pyramid are not allowed within the higher designations (e.g., commercial uses are not allowed in multi-family zones, and apartments are not allowed in single-family zones). This is giving way to a much more sustainable model, where the middle of the pyramid consists of mixed-use development that integrates housing, commercial, and recreational/cultural activities. Despite the desirability of mixed-use zoning, it is important to recognize that there are certain industrial uses that will always be incompatible with residential and school uses.

Residential and school uses are harmed by incompatible land uses that have environmental effects, such as noise, air emissions (including dust), and exposure to hazardous materials. The compatibility problem also operates in reverse. Incompatible uses adjacent to residential units, schools, or environmentally sensitive areas may also suffer negative consequences in the form of higher mitigation costs or the curtailment of economic activities. Specific examples of land use incompatibility include:

♦ Residential and school uses in proximity to industrial facilities and other uses that, even with the best available technology, will contain or produce materials that, because of their quantity, concentration, or physical or chemical characteristics, pose a significant hazard to human health and safety.
♦ Residential and school uses adjacent to intensive agricultural uses.
♦ Residential and school uses adjacent to major thoroughfares, such as highways.
♦ Residential or commercial uses in proximity to resource utilization activities, such as mining or oil and gas wells.

Issues related to industrial overconcentration and the location of industrial dwellings and schools are discussed below.

Information and Analysis

Good information is critical to making informed decisions about environmental justice issues. The analysis of environmental justice problems has benefited from the advancement of geographic information systems (GIS), as has the entire planning field. The role of data in the general plan process is discussed more fully in Chapter 3. The data suggestions for the mandatory general plan elements (Chapter 4) include much of the information necessary for developing environmental justice policies.

Relevant information for addressing environmental justice issues includes, but is not limited to:

♦ Base map of the city or county planning area.
♦ General plan designations of land use (existing and proposed).
♦ Current demographic data.
  ➢ Population location and density.
  ➢ Distribution of population by income.
  ➢ Distribution of population by ethnicity.
  ➢ Distribution of population by age.
♦ Location of public facilities that enhance community quality of life, including open space.
♦ Location of industrial facilities and other uses that contain or produce materials that, because of their quantity, concentration, or physical or chemical characteristics, pose a significant hazard to human health and safety.
♦ Location of existing and proposed schools.
♦ Location of major thoroughfares, ports and airports.
♦ Location and density of existing and proposed residential development.
Although the use of population data is a normal part of the planning process, cities and counties do not always gather socioeconomic data when preparing or substantially revising their general plans. Jurisdictions do have to collect some socioeconomic data during the preparation of the housing element, such as income level and persons with special housing needs (elderly, farmworkers, single head of household, etc.), but this required information is not enough to paint a complete socioeconomic picture of the community. From an environmental justice perspective, socioeconomic data is useful for a number of things, including:

- Improving the public participation process.
- Identifying low-income and minority neighborhoods that are underserved by public facilities and services that enhance quality of life and planning for the equitable distribution of such facilities and services.
- Planning for infrastructure and housing needs.
- Identifying low-income and minority neighborhoods in which industrial facilities and uses that pose a significant hazard to human health and safety may be overconcentrated.

As discussed below, the definitions of both equitable distribution and overconcentration do not depend on socioeconomic factors. However, reversing historical problems of procedural and geographic inequity requires accurate socioeconomic information in order to develop policies and prioritize implementation measures.

Relationship to the General Plan

Cities and counties may incorporate environmental justice into their general plans in several ways. A city or county may choose to adopt an optional environmental justice element. However, OPR recommends incorporating policies supportive of environmental justice in all of the mandatory elements of the general plan. These policies should also be reflected in any optional elements. In keeping with the internal consistency requirement, environmental justice policies in one element cannot conflict with the policies of another element. For example, if the land use element contains a policy prohibiting residential uses adjacent to certain industrial uses, properties affected by that policy could not be used as part of the housing element site inventory.

Public Facilities and Services

Cities and counties should plan for the equitable distribution throughout the community of new public facilities and services that increase and enhance community quality of life, given the fiscal and legal constraints that restrict the siting of such facilities.

Public facilities and services that enhance quality of life include, but are not limited to, parks, open space, trails, greenbelts, recreational facilities (including senior and youth centers), community centers, child care centers, libraries, museums, cultural centers, science centers, and zoos. The equitable distribution of facilities and services has two components. The first component is the number and size of facilities. Simply put, a community should have adequate facilities and services to serve all residents equally. The second component is access, which can be measured as the distance or travel time from each residential area to the facility or service. Access may also be measured by the ability to use a variety of transportation modes, including public transit, walking, and bicycling, to travel between each residential area and the facility or service. A geographic analysis of residential areas and the location of public amenities may reveal underserved neighborhoods. Policies addressing the distribution of beneficial public facilities and services should address existing disparities as well as the needs of future residents.

Public facilities and services that enhance community quality of life can be divided into three basic types for purposes of distribution. The first type is neighborhood facilities, such as parks, that serve a specific neighborhood or subdivision. The second type is district facilities, such as branch libraries or recreational centers, that serve more than one neighborhood. The third type is unique facilities, where one facility serves the entire community—“community” being an incorporated city or, for counties, an unincorporated area.

Neighborhood facilities should be geographically dispersed throughout the community. Examples include parks, tot lots, and neighborhood activity centers. These facilities should be located within the neighborhood they serve. Public amenities can serve to anchor a neighborhood and should be centrally located. Furthermore, locating neighborhood-serving public facilities within walking distance of most residents will encourage use and provide a sense of place. A distance of a quarter to a half mile is generally considered a walkable distance.

Planning for the location of district facilities should follow the same principles as above. Since these facilities serve several neighborhoods, they should be centrally located relative to the neighborhoods they serve. Locating such facilities along transit corridors or in transit-oriented developments will increase their accessibility (see Transit-Oriented Development later in this chapter).

Examples of unique public facilities include the central library or city museum. Where a community has
only one recreational or cultural center, that would be considered a unique facility or service. These facilities should be located in the civic center or urban core rather than isolated in remote single-use complexes. They should be close to transit to allow maximum access for the entire community.

Consideration should also be given to regional facilities, which may exhibit the characteristics of all three basic types described above. Regional facilities include trails, networks of open space such as greenbelts, regional parks and recreation areas, etc. Linear facilities (such as trails and greenbelts) may serve several neighborhoods but are also a unique amenity for the entire area. The same is true of large regional recreational areas. Individual cities and counties may have less control over the location of regional facilities, which may be operated by special districts or joint powers authorities. Cities and counties have even less control over state and federal parks, recreational areas, and forests, although cities and counties should account for such facilities in the planning process. New regional facilities are rare, and when the opportunity to acquire or develop such facilities arises, the location may be predetermined by such factors as natural features, abandoned rail lines (for trail use), or the availability of large undeveloped properties. Nevertheless, planners should consider existing and proposed regional facilities when analyzing community access to public facilities that contribute to quality of life and when planning for future such facilities.

Locating public facilities and uses according to these planning principles may be limited by fiscal and legal constraints. Fiscal constraints include the relative cost of land and the ability of public agencies to obtain financing for acquisition and construction. Legal constraints include, but are not limited to, local, state, and federal regulations for the protection of the environment, public health and safety, and the preservation of natural and cultural resources, including historical and archeological resources.

Industrial Facilities

Cities and counties should develop policies that provide for the location of industrial facilities and other uses that, even with the best available technology, will contain or produce materials that, because of their quantity, concentration, or physical or chemical characteristics, pose a significant hazard to human health and safety in a manner that seeks to avoid overconcentrating these uses in proximity to schools or residential dwellings.

Overconcentration occurs when two or more industrial facilities or uses, which do not individually exceed acceptable regulatory standards for public health and safety, pose a significant hazard to adjacent residential and school uses due to their cumulative effects.

Facilities that emit, handle, store, or dispose of hazardous materials are regulated by a variety of agencies. These agencies include local Certified Unified Program Agencies (such as environmental health departments or fire departments), air districts, regional water quality control boards, the California Department of Health Services, the California Integrated Waste Management Board, and the California Department of Toxic Substance Control (DTSC). However, cities and counties, as the local land use authority, are primarily responsible for the location and distribution of potentially hazardous industrial facilities through their general plans and zoning ordinances.

Cities and counties may pursue several strategies within their general plans to address overconcentration. Strategies may include:

- Buffer zones between industrial and residential land uses.
- Policies addressing individual project siting decisions.
- Capping the number of certain facilities and uses.
- Changing land use designations in overconcentrated areas.

Buffer zones are a broad approach to land use compatibility. Buffer zone policies may be approached in one of two ways. First, the general plan land use diagram may designate transitional land uses between industrial and residential areas. Transitional uses may include open space, light industry, office uses, business parks, or heavy commercial uses. The land use policies for these buffer areas should prohibit school uses (see discussion below on school siting). Appropriate distances for buffer areas will vary depending on local circumstances. Factors such as the intensity of nearby residential uses, prevailing

Analyzing Equitable Distribution

A University of Southern California study, Parks and Park Funding in Los Angeles: An Equity Mapping Analysis, is an example of how equitable distribution of public amenities (in this case, parks and open space) can be analyzed using a geographic information system (GIS). The report is available at www.usc.edu/dept/geography/espe.
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winds, geographic features, and the types of facilities and uses allowed in industrial areas should be considered.

Second, buffer zones may be implemented at the project level. One weakness of general buffer zone policies is the difficulty of making a priori decisions about how much distance is needed to minimize potential health and safety hazards to residential and school uses. A stronger approach may be buffer policies aimed at individual siting decisions.

Approval of certain industrial facilities or uses can be made conditional if they are within a certain distance of residential or school uses and/or contain or produce hazardous materials. This allows the city or county to consider the potential hazards associated with individual facilities or uses on a case-by-case basis. General plan policies can outline consistent standards to be used in approving, conditionally approving, or denying proposed locations for industrial facilities and other uses that may pose a significant hazard to human health and safety. Such standards should be reflected in the zoning ordinance that implements the general plan (see Chapter 10 for a discussion of zoning consistency).

Approval of a conditional use is discretionary and thus would be subject to the California Environmental Quality Act (CEQA). CEQA requires decision makers to consider the environmental consequences of their actions. CEQA also serves as an important consultation tool. A lead agency must consult with an affected school district if any facility that would create hazardous materials is proposed within a quarter mile of a school (Public Resources Code §21151.4).

Another policy response to overconcentration is to cap the number of potentially hazardous facilities within a certain distance of each other. For example, the State of Georgia does not allow siting of a new solid waste facility if two such facilities already exist within a two mile radius of the proposed facility. While capping policies are easy to implement and understandable to the public, they have serious drawbacks. Numerical caps are more likely to be based on perception and political compromise than scientific merit. Without analyzing the type, quantity, and concentration of materials to be contained or produced at a proposed facility, it is difficult to determine the number of facilities that would create a situation of overconcentration.

The general plan strategies above can assist a city or county in addressing future problems of overconcentration. General plans, which are by their nature concerned with future development, are not as effective at correcting past problems. One way to address existing or potential future problems of overconcentration is to change the land use designation for existing industrial areas. This approach differs from buffer zones in that buffer zones affect the land use designation of areas adjacent to existing or proposed industrial areas. Changing the allowable land uses in existing industrial areas prevents new industrial land uses from being established and may affect the expansion of existing facilities and uses (depending on how local policies treat pre-existing or “legal non-conforming,” land uses).

An important caveat is to consider what new uses will be allowed in the previously industrial areas. A new environmental justice problem could be created if residences and schools are allowed without considering any lingering effects of industrial overconcentration. At the same time, where overconcentration is no longer an issue and effective remediation or clean-up is possible, so-called “brownfield” development is an important tool for a community’s continued sustainable development.

Finally, planners should remember to differentiate between overconcentration and the mere presence of materials that may be classified as hazardous. Many neighborhood businesses, such as gas stations, photography studios, retail paint stores, dry cleaners, etc., may have hazardous materials present. While these activities must be conducted in a responsible manner in accordance with all environmental regulations, they should not be confused with those truly industrial activities that are inappropriate for residential or mixed-use areas.

**New Residential Uses and Schools**

Cities and counties should provide for the location of new schools and residential dwellings in a manner that seeks to avoid locating these uses in proximity to industrial facilities and uses that will contain or produce materials that, because of their quantity, concentration, or physical or chemical characteristics, pose a significant hazard to human health and safety.

The location of new residential and school development is the flip side of the problem discussed in the section above. Given the need for new housing and schools and given the need to make efficient use of land, how do cities and counties deal with existing overconcentration of industrial uses? When designating areas for residential development, the city or county should identify any areas of overconcentration. Appropriate buffers should be placed between overconcentrated industrial areas and new residential areas. Using their authority over the approval and design of subdivisions, cities and counties may develop

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policies and standards related to industrial overconcentration and new residential subdivision approvals. These policies could include buffer zones, as well as the criteria to be used for rejecting new residential development (such as standards for risk to human health and safety from nearby industrial facilities and uses).

The location of new schools is of particular concern to both local governments and school districts. The general plan should identify possible locations for new schools. Such locations may be approximate and need not indicate specific parcels. Identifying appropriate school locations as part of the general plan process may avoid project-level problems of proximity to certain industrial facilities and uses. Due to the fragmentation of authority in the areas of land use planning and school siting and construction, it is recommended that the planning agency work closely with the school district to identify suitable school locations. Prior to adopting or amending a general plan, the planning agency must refer the proposed action to any school district within the area covered by the proposed action (§65352). The city or county should use this opportunity to engage school districts on issues of school siting.

For their part, school districts are required to notify the planning commission of the city or county prior to acquiring property for new schools or expansion of an existing school. School districts are not bound by local zoning ordinances unless the ordinance provides for the location of schools and the city or county has adopted a general plan (§53091). School districts can override the general plan and zoning ordinances with regard to the use of property for classroom facilities by a two-thirds vote of the school board (§53094). The school board cannot exercise this power for non-classroom facilities, such as administrative buildings, bus storage and maintenance yards, and warehouses. If the school board exercises their override power, they must notify the city or county within 10 days (§53904).

CEQA requires that the environmental document prepared for a new school identify whether the proposed site is any of the following: a current or former hazardous waste or solid waste disposal facility, a hazardous substances release site identified by DTSC, the site of one or more pipelines that carry hazardous substances, or located within a quarter mile of a facility that emits hazardous air emissions or handles acutely hazardous material (Public Resources Code §21151.8). If such facilities exist, the school board must make findings that the facilities would not endanger the health of those attending or employed by the proposed school or that existing corrective measures would result in the mitigation of any health endangerment.

**TRANSIT-ORIENTED DEVELOPMENT**

Cities and counties should promote more livable communities by expanding opportunities for transit-oriented development (TOD) so that residents minimize traffic and pollution impacts from traveling for purposes of work, shopping, school, and recreation.

TOD is defined as moderate- to high-density development located within an easy walk of a major transit stop, generally with a mix of residential, employment, and shopping opportunities. TOD encourages walking and transit use without excluding the automobile. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use (*Statewide Transit-Oriented Development Study: Factors for Success in California, California Department of Transportation, 2002*).

A well-designed, vibrant TOD community can provide many benefits for local residents and businesses, as well as for the surrounding region. Compact development near transit stops can increase transit ridership and decrease rates of vehicle miles traveled (VMT), thereby yielding a good return on transit system investments. TOD can also provide mobility choices, increase public safety, increase disposable household income by reducing transportation costs, reduce air pollution and energy consumption rates, help conserve resources and open space, assist in economic development, and contribute to the housing supply.

TOD is a strategy that may help a community achieve its general plan goals related to circulation, housing, environmental quality, and economic development. Additionally, by improving access to jobs and housing and revitalizing existing neighborhoods, TOD can be a tool for promoting environmental justice.

A variety of factors need to be considered during the development and implementation of TOD. These factors include transit system design; community partnerships; understanding of local real estate markets; coordination among local, regional, and state organizations; and providing the right mix of planning and financial incentives and resources. A successful TOD will reinforce the community and the transit system. Transit operators, property owners, and residents should be involved in the development of TOD proposals.

Data to identify and assess potential locations for TOD should be collected during preparation of the land use, circulation, and housing elements of the general plan. An inventory of potential development (and redevelopment) sites within a quarter to a half mile of existing and proposed transit stops may reveal potential locations for TOD. Additional data may be used to verify the optimum location and mix of uses to further refine...
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the viability of TOD at specific transit hubs. This data may include origin and destination studies, transit ridership projections, and data to determine the appropriate jobs-to-housing ratio and level of retail services. The appropriate density and intensity will support a high level of transit service. An optimal mix of uses will provide opportunities to shop, work, live, and recreate without the need for an automobile.

Local governments can promote TOD through general plan policies that encourage supportive densities and designs and a mix of land uses. TOD-supportive policies may provide for higher land use densities, reduced parking requirements, decreased automobile traffic levels of service, and increased transit levels of service. TOD policies should facilitate a pedestrian-oriented environment with features such as traffic calming strategies, traditional grid street patterns with smaller blocks, and architecture that orients buildings to sidewalks, plazas, and parks rather than to parking.

TOD Standards and Policies

TOD design will vary with local needs and context, but there are several generally accepted characteristics. These characteristics should be addressed broadly in general plan policies and standards. Policies for specific neighborhood districts or development sites can be implemented through the planning tools discussed at the end of this section.

Density

Density is a key concern in designing TOD policies. A higher residential density relative to the community as a whole is necessary to achieve a high level of transit service and maximize the use of land suitable for such developments. Density levels vary significantly based on local circumstances, but a minimum of 15 to 25 units per acre may be required to sustain an appropriate level of transit use and commercial activity. The location of the TOD (regional urban core, town center, suburban development, etc.) and the mix of uses envisioned for a particular TOD will affect the optimal level of density and intensity.

Mixed Use

A mix of uses is also a key element in TOD. Mixed-use development facilitates a pedestrian-oriented environment, encouraging walking and transit over automobile trips. A mix of uses also creates an environment that encourages both day and night activity. For example, residential development supports restaurants and entertainment uses after regular work hours have ended. This can increase safety by avoiding the “dead zone” atmosphere that many residential areas have by day and that many downtowns and commercial districts have in the evening. Public uses also can contribute to the success of TOD. Some TODs are anchored by a public facility, such as a police station, child care center, recreation center, or government office. Not only does a TOD benefit from the presence of public amenities, but the public also benefits by having these amenities convenient to transit.

A mix of uses may be within the same building (such as first-floor commercial with residential units above) or in separate buildings within a quarter to a half mile of the transit stop. Particularly with the latter case, referred to as “horizontal mixed-use,” it is important to provide safe and direct pedestrian linkages between different uses.

It is recommended that general plan standards and definitions of mixed-use development exclude industrial facilities and uses that, even with the best available technology, will contain or produce materials that, because of their quantity, concentration, or physical or chemical characteristics, pose a significant hazard to human health and safety.

Pedestrian Scale

With higher-density mixed-use development, scale is important. Pedestrian scale should be maintained through appropriate street and sidewalk widths, block lengths, the relationship of the buildings to the street, and the use of public spaces.

Safety

In addition to the round-the-clock activity mentioned above, it is important to maintain “eyes on the street” in urban development through the appropriate placement of windows and entrances. Appropriate lighting also contributes to safety and the attractiveness of the development.

Landscaping

A TOD, particularly when it is infill development, may not have large areas available for landscaping. Nevertheless, high quality landscaping should be used to enhance public spaces. The generous use of trees creates a more livable environment and reduces energy costs for cooling. Street trees can make development more pedestrian friendly by providing a barrier between the sidewalk and street.

Circulation

Circulation within a TOD should, in addition to supporting transit, maximize walking and bicycling without eliminating the automobile. Cities and counties may designate certain qualifying areas served by transit as
CASE STUDY: Integrating Transit-Oriented Development into the General Plan

The following policies from the agriculture and land use element of the Fresno County General Plan illustrate how local jurisdictions can facilitate and guide transit-oriented development:

**Policy LU-F1** The County shall encourage mixed-use development that locates residences near compatible jobs and services.

**Policy LU-F2** The County shall encourage the combination of residential, commercial, and office uses in mixed use configurations on the same site.

**Policy LU-F3** The County shall promote development of higher-density housing in areas located along major transportation corridors and transit routes and served by the full range of urban services, including neighborhood commercial uses, community centers, and public services.

**Policy LU-F4** The County shall selectively redesignate vacant land for higher density uses or mixed uses to facilitate infill development.

**Policy LU-F5** The County shall encourage subdivision designs that site neighborhood parks near activity centers such as schools, libraries, and community centers.

**Policy LU-F6** The County shall encourage the creation of activity centers including schools, libraries, and community centers in existing neighborhoods.

**Policy LU-F7** The County shall seek to reduce the amount of land devoted to parking in new urban non-residential development and encourage the use of shared parking facilities.

**Policy LU-F8** The County shall adopt transit- and pedestrian-oriented design guidelines and incorporate them into community plans and specific plans. The County shall review development proposals for compliance with its adopted transit-and pedestrian-oriented design guidelines to identify design changes that can improve transit, bicycle, and pedestrian access.

**Policy LU-F9** The County shall plan adequate pedestrian-oriented neighborhood commercial shopping areas to serve residential development.

**Policy LU-F10** The County shall encourage school districts to site new schools in locations that allow students to safely walk or bicycle from their homes, and to incorporate school sites into larger neighborhood activity centers that serve multiple purposes.

“infill opportunity zones.” (§65088.1) These zones, which must be identified by December 31, 2009, are exempt from county Congestion Management Plan level of service requirements (§65088.4).

**Parking**

Parking requirements for TOD are typically lower than for conventional development and often specify a maximum rather than a minimum number of spaces. In order to maximize the use of land, parking structures are favored over surface parking, particularly at infill TOD sites. The placement of parking structures should not physically separate the TOD from the surrounding community.

**Implementation Tools**

Successful TOD implementation is dependent upon TOD-supportive general plan policies enabled by specific zoning codes, development regulations, and design guidelines. To create an effective regulatory and review environment, local jurisdictions can modify existing zoning codes to encourage TOD; tailor development regulations to individual TOD sites where appropriate; develop TOD-friendly design sites; and simplify and streamline the permit and review process.

The following planning tools are typical ways a community can implement TOD-supportive general plan policies.
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CASE STUDY: Integrating Transit-Oriented Development into the General Plan

The following policies from the 1998 City of Oakland General Plan illustrate how local jurisdictions can facilitate and guide transit-oriented development:

**Goal:** Integrate land use and transportation planning. Integrate transportation and land use planning at the neighborhood, city, and regional levels by developing transit-oriented development where appropriate at transit and commercial nodes.

**Objective:** Provide mixed use, transit-oriented development that encourages public transit use and increases pedestrian and bicycle trips at major transportation nodes.

**Policy 1:** Encourage Transit-Oriented Development. Transit-oriented development should be encouraged at existing or proposed transit nodes, defined by the convergence of two or more modes of public transportation such as BART, bus, shuttle service, light rail or electric trolley, ferry, and inter-city or commuter rail.

**Policy 2:** Guiding Transit-Oriented Development. Transit-oriented developments should be pedestrian oriented, encourage nighttime and daytime use, provide the neighborhood with needed goods and services, contain a mix of land uses, and be designed to be compatible with the character of surrounding neighborhoods.

**Policy 3:** Promoting Neighborhood Services. Promote neighborhood-serving commercial development within one-quarter to one-half mile of established transit routes and nodes.

**Policy 4:** Linking Transportation and Economic Development. Encourage transportation improvements that facilitate economic development.

**Policy 5:** Linking Transportation and Activities. Link transportation facilities and infrastructure improvements to recreational uses, job centers, commercial nodes, and social services (e.g., hospitals, parks, or community centers).

To encourage pedestrian use, the entire village must be contained within a one-quarter mile radius of a transit station. The Act provides that a city or county adopting a plan will be eligible for state transportation funds but does not indicate that areas with such plans will receive priority funding. Transit villages may be excluded from conformance with county Congestion Management Plan level of service standards with the approval of the Congestion Management Agency.

**Specific Plan**

Specific plans are a useful zoning tool for implementing the TOD-related policies and objectives of the general plan. A specific plan can provide detailed land use policies, development standards, and infrastructure requirements in the TOD area. For a further discussion of specific plans, see Chapter 10 as well as the OPR publication The Planner’s Guide to Specific Plans.

**Transit Village Plan**

The Transit Village Development Planning Act of 1994 (§65460, et seq.) authorizes cities and counties to prepare “transit village plans” to encourage mixed-use development in close vicinity to transit stations. Transit village plans occupy a niche similar to the community plans described in Chapter 1. What distinguishes them is their specific role in encouraging high-density pedestrian-oriented development around transit stations.

A transit village plan must be consistent with the city or county general plan (§65460.8). The plan is adopted by resolution, like the general plan, and becomes the policy foundation for village zoning provisions, public works projects, and future subdivision activity.

**Zoning**

Transit-oriented development will typically involve changes in zoning, either as a separate action or in conjunction with a specific plan or a transit village plan. The purpose of the rezoning is to specify uses and allow the necessary density and building intensity for a successful TOD. Zoning changes may take the form of a new zoning district or an overlay zone. Planned unit development (PUD) zoning may also be used for TOD. Considerations for TOD zoning include mixed-use, minimum residential densities, intensity of commercial and office uses, appropriate automobile parking standards, and optimal building setbacks to create pedestrian scale.
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California Energy Commission
Public Interest Energy Research Program

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July 2003
500-04-073
Prepared By:
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Contract No. 500-01-006
Work Authorization No. 17-AB-01

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Acknowledgements

This work was supported by a number of sources, including the Dialogue on Water and Climate, Government of the Netherlands, the Public Interest Energy Research Program (PIER) of the California Energy Commission, the California Department of Water Resources, and the John D. and Catherine T. MacArthur Foundation. We thank them for their support. All conclusions are, of course, our own.

Another product of this effort is a new, searchable, electronic bibliography of the water and climate literature. Over 3,000 citations are available to be searched by title, author, keyword, region, and more, at www.pacinst.org/resources.

The Public Interest Energy Research Program (PIER) of the California Energy Commission is an integrated, multidisciplinary effort to explore the potential implications of climate change for California's economy, ecosystems, and health. Designed to complement national and international studies, the project will provide California-specific but preliminary information on climate change impacts. Many efforts are already underway, and the section Research Needs describes future priorities. For example, PIER is funding a climate change research program of core research activities at UC Berkeley and UC San Diego (Scripps). Scripps is developing a comprehensive meteorological and hydrological database for the state representing historical conditions for the last 100 years. The database will be very useful for regional model inter-comparison work and the study of climatic trends. Scripps is also testing a dynamic regional climate model (Regional Spectral Model) simulating climatic conditions in California for the last 50 years, and they are testing new statistical downscaling techniques with the goal of capturing extreme events. Finally, they are installing meteorological and hydrological sensors in key areas/transects in California to track a changing climate and provide a richer database for future regional model enhancements and evaluations.

This paper grew out of a collaborative exchange of ideas by DWR’s California Water Plan Update (Bulletin 160-2003) Climate Change Working Group (CCWG), in which both the authors participated. Many of the participants in the CCWG contributed to these early efforts, particularly Maury Roos.

The authors would like to acknowledge the following individuals for their thoughts, comments, and suggestions: Guido Franco was the project manager at the California Energy Commission. His enthusiasm and patience are appreciated. Thanks also to Kelly Birkinshaw for support. We also thank:

- Dr. Dan Cayan, Scripps Institute of Oceanography, University of California, San Diego, La Jolla.
- Mr. Maury Roos, California Department of Water Resources, Sacramento.
- Mr. Kamyar Guivetchi, California Department of Water Resources, Sacramento.
- Mr. Jonas Minton, California Department of Water Resources, Sacramento.
- Mr. Sergio Guillen, California Bay-Delta Authority, Sacramento.
Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Strategic Energy Research

What follows is the final report for the California Water Policy and Climate Change project, contract number 500-01-006, work authorization 17-AB-01, conducted by the Pacific Institute for Studies in Development, Environment, and Security. The report is entitled *Climate Change and California Water Resources: A Survey and Summary of the Literature*. This project contributes to the PIER Energy-Related Environmental Research program.

For more information on the PIER Program, please visit the Energy Commission’s Web site at: [www.energy.ca.gov/pier](http://www.energy.ca.gov/pier), or contact the Energy Commission at (916) 654-4628.
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Abstract

The Pacific Institute surveyed existing literature on climate change and its impacts on water resources in California. The study reviewed projected effects of climate change on the state’s water supply, delivery, and quality, and explored the economics involved in meeting the challenges that those effects could bring about.

The study concluded that managing water resources to address climate change impacts could prove different than managing for historical climate variability because: (1) climate changes could produce hydrologic conditions and extremes of a different nature than current systems were designed to manage; (2) they may produce similar kinds of variability but outside of the range for which current infrastructure was designed; (3) traditional water resource management assumes that sufficient time and information will be available before the onset of large or irreversible climate impacts to permit managers to respond appropriately; (4) traditional management assumes that no special efforts or plans are required to protect against surprises or uncertainties.

The literature survey identified specific recommendations for the following areas:

- Water planning and management
- Sea level concerns
- Modifying operation of existing systems
- New supply options
- Demand management, conservation, and efficiency
- Economics, pricing, and markets
- State water law
- Hydrologic and environmental monitoring

A more comprehensive assessment of all of these areas, supported by multiple state agencies and including the participation of a wide range of stakeholders, could be a valuable tool for policymakers and planners, and the researchers urge such an assessment to be undertaken in the near future.
Executive Summary

Objectives
Some of the most significant impacts of climate change will be on water resources—impacts that are of special concern to regions like California where water policy is already of great interest and concern.

Evidence of climate change impacts on California’s hydrologic system have already appeared in various forms. Water agencies around the State have begun to consider the implications of climate change for the reliability and safety of water systems, and professional water organizations have begun urging managers and planners to integrate climate change into long-term planning. Although many uncertainties remain, responsible planning requires that the California water community work with climate scientists and others to reduce those uncertainties and to begin to prepare for those impacts that are well understood, already appearing, or likely to appear.

Substantial work has been done at the international and national level to evaluate climatic impacts, but far less information is available on regional and local impacts. This paper begins the process of summarizing some of the consequences of climate change for water resources and water systems in California.

Outcomes
Researchers identified issues and research related to climate change impacts on California’s natural and managed water systems. They also identified a number of reports that outline impacts of climate change on water resources and recommendations for addressing those impacts. This report classified those recommendations into four categories: Current No-Regrets Actions, Communication and Collaboration, Research Needs, and Information Gathering. Researchers noted that none of the reports contradicted each other on any specific recommended measure.

Conclusions, Recommendations, and Benefits to California
The study concluded that managing water resources to address climate change impacts could prove different than managing for historical climate variability because: (1) climate changes could produce hydrologic conditions and extremes of a different nature than current systems were designed to manage; (2) they may produce similar kinds of variability but outside of the range for which current infrastructure was designed; (3) traditional water resource management assumes that sufficient time and information will be available before the onset of large or irreversible climate impacts to permit managers to respond appropriately; (4) traditional management assumes that no special efforts or plans are required to protect against surprises or uncertainties.
The study identified the following information and recommendations:

- **Water planning and management**: Water planners and managers must increase emphasis on trying to understand the consequences of climate change on the state’s water resources.

- **Sea level concerns**: To increase levee height of the 520 miles of levees that are outside the federal flood control project (to accommodate sea level rise) would cost $300 million above the $613 million to $1.28 billion that is already necessary to bring them up to Public Law 84-99 standard.

- **Modifying operation of existing systems**: Managers must determine if existing facilities can handle the impacts that will occur under future climate change, and at what economic cost. Precise information on future climate impacts is unavailable, so water managers must explore the sensitivity of their system to a wider range of conditions, and develop methods or technologies to improve operational water management. They should also determine quantitative impacts from climate change on water supply and flood control, and evaluate alternative water management options. In addition, water managers should closely examine the design practices of hydraulic infrastructure, because of the many uncertainties in predicting peak flows under climate change scenarios. Rainfall depth-duration-frequency data widely used for designing local storm water control and drainage facilities could be updated at least every 20 years or so, to gradually incorporate climate change data into the record and in the rainfall statistics.

- **New supply options**: Supply designs and operations must consider climate change impacts and incorporate wastewater reclamation and reuse, water marketing and transfers, and limited desalination, where it is cost-effective. Designs for new construction must be robust enough to permit satisfactory operation under a wide range of conditions.

- **Demand management, conservation, and efficiency**: Demand management is critical to mitigate loss of water supply. Efficient management should continue to be developed and implemented, because such improvements have been shown to be more economical than developing new supply.

- **Economics, pricing, and markets**: New pricing mechanisms should be used to better recognize the true costs of water supply and to support water markets.

- **State water law**: Current water laws were written without considering climate change impacts on water supply. They are predicted to conflict with one another as water resources diminish.

- **Hydrologic and environmental monitoring**: Good hydro-meteorological data are the starting point for evaluating the capabilities of water supply and flood protection systems. Important data gaps need to be filled in the following areas: measurements of precipitation and related climate data, streamflow, snowpack, and ocean and Delta water levels; water quality sampling; systematic sea-level measurements; and land use and cover monitoring.
A more comprehensive assessment of all of these areas, supported by multiple state agencies and including the participation of a wide range of stakeholders, could be a valuable tool for policymakers and planners, and the researchers urge such an assessment to be undertaken in the near future.
1.0 Introduction

1.1. Background and Overview

The issue of global climate change has begun to play an increasing role in scientific and policy debates over effective water management. In recent years, the evidence that global climate change will have significant effects on water resources in California has continued to accumulate. More than 150 peer-reviewed scientific articles on climate and water in California have now been published, with many more in preparation, addressing everything from improvements in downscaling of general circulation models to understanding how reservoir operations might be adapted to new conditions.

California water planners and managers have been among the first in the nation to consider these issues, though most efforts in this field have been both modest and informal. Initial research and analysis on climate risks facing California water resources began in the early 1980s and by the end of the decade state agencies such as the California Energy Commission had prepared the first assessments of state greenhouse gas emissions and possible impacts to a wide range of sectors. The California Water Plan (Bulletin 160) first briefly addressed climate change in 1993. More recently, the Public Interest Energy Research program (PIER) of the California Energy Commission has reinvigorated scientific research at the state level to explore a wide range of climate impacts and risks, including risks to water resources. Other state agencies, such as the California Department of Water Resources, have also revived an interest in these issues (see the Acknowledgement Section and the Research Needs summary; see also a draft summary document from PIER by Wilson et al. 2003).

In recent years, the scientific consensus has broadened that climate changes will be the inevitable result of increasing concentrations of greenhouse gases. There is also a growing consensus that various anthropogenic climate impacts are already appearing worldwide. Evidence of its impacts on California’s hydrologic system has also appeared in various forms. Water agencies around the State have begun to consider the implications of climate change for the reliability and safety of water systems, and professional water organizations have begun urging managers and planners to integrate climate change into long-term planning. In 1997, the American Water Works Association issued a committee report concluding that “Agencies should explore the vulnerability of both structural and nonstructural water systems to plausible future climate changes, not just past climatic variability” and “Governments at all levels should reevaluate legal, technical, and economic approaches for managing water resources in light of possible climate changes” (AWWA 1997).

Many uncertainties remain. Responsible planning, however, requires that the California water community work with climate scientists and others to reduce those uncertainties and to begin to prepare for those impacts that are well understood, already appearing, or likely to appear.

Climate change is a scientific reality. The broad consensus of the scientific community is that greenhouse gases emitted by human activities are accumulating in the atmosphere and that these gases will cause a wide range of changes in climate dynamics, especially
the accumulation of terrestrial radiation (IPCC 2001). Some of the most significant impacts will be on water resources—impacts that are of special concern to regions like California where water policy is already of great interest and concern (Gleick and others 2000; Wilkinson and others 2002). As concentrations of these gases continue to increase, greater amounts of terrestrial radiation will become trapped, temperatures will rise further, and other impacts will become more significant.

1.2. Project Approach
Substantial work has been done at the international and national level to evaluate climatic impacts, but far less information is available on regional and local impacts. This paper begins the process of summarizing some of the consequences of climate change for water resources and water systems in California. A more comprehensive assessment, supported by multiple state agencies and including the participation of a wide range of stakeholders could be a valuable tool for policymakers and planners, and we urge such an assessment to be undertaken in the near future.

1.3. Report Organization
Section 2 provides an overview of climate change’s impacts on California’s water resources. Section 3 discusses observed water trends for water temperature, precipitation, runoff, and variability and extreme events for the state. Section 4 covers climate change impacts on California’s managed water systems. Section 5 outlines policy directions in addressing water issues. Section 6 identifies specific policy actions.

2.0 Climate Change and Impacts on California Water Resources

2.1. Overview of Modeling
Projecting regional impacts of climatic change and variability relies first on General Circulation Models (GCMs), which develop large-scale scenarios of changing climate parameters, usually comparing scenarios with different concentrations of greenhouse gases in the atmosphere. This information is typically at too coarse a scale to make accurate regional assessments. As a result, more effort has recently been put into reducing the scale and increasing the resolution of climate models through various techniques such as downscaling or integrating regional models into the global models. The resulting finer-scale output can then be analyzed for given watersheds, ideally with the incorporation of other hydrologic parameters such as local evaporation, transpiration, soil conditions, topography, snowpack, and groundwater.

Models are typically calibrated by comparing model runs over historical periods with observed climate conditions. It should be emphasized that these model results are not intended as specific predictions, but rather are scenarios based on the potential climatic variability and change driven by both natural variability and human-induced changes. Nonetheless, they are useful for assessing potential possible future conditions.
2.2. Temperature

Modeling results from GCMs are consistent in predicting increases in temperatures globally with increasing concentrations of atmospheric greenhouse gases resulting from human activity. Higher temperatures are of particular interest and concern for California water systems because of their effect on Sierra snowpack accumulation and snowmelt and other hydrologic variables, addressed below. Recent work by Snyder et al. (2002) has produced the finest-scale temperature and precipitation estimates to date. Resulting temperature increases for a scenario of doubled CO$_2$ concentration are 1.4–3.8 degrees C throughout the region (Figure 1). This is consistent with the global increases predicted by the Intergovernmental Panel on Climate Change (2001). Sample temperature results from two different GCMs are also presented below in Figures 2a and 2c. In a regional model of the Western United States, Kim et al. (2002) project a climate warming of around 3 to 4 degrees C. Of note in both studies is the projection of uneven distribution of temperature increases. For example, regional climate models show the warming effects are greatest in the Sierra Nevada Mountains, with implications for snowpack and snowmelt (Kim et al. 2002; Snyder et al. 2002). Similar results have been noted in Barnett et al. (in review).

2.3. Precipitation

In general, while modeling of projected temperature changes is broadly consistent across most modeling efforts, there are disagreements about precipitation estimates. Considerable uncertainties about precise impacts of climate change on California hydrology and water resources will remain until we have more precise and consistent information about how precipitation patterns, timing, and intensity will change. Some recent regional modeling efforts conducted for the western United States indicate that overall precipitation will increase (Giorgi et al. 1998; Kim et al. 2002; Snyder et al. 2002), but considerable uncertainty remains due to differences among larger-scale GCMs (Figures 1 and 2). Where precipitation is projected to increase, the increases are centered in Northern California (Kim et al. 2002; Snyder et al. 2002, Figure 1) and in winter months. More general large-scale precipitation results from two different GCMs are also presented below in Figures 2b,d. Further work is in progress to extend and improve these modeling efforts, and to use watershed-scale hydrological models that will be of more direct value to planners.
Figure 1. Comparison of modeling results for a baseline CO₂ scenario (column 1) and doubled CO₂ scenario (column 2). Column 3 shows the differences between the two scenarios. Panels A, D, and G compare modeled surface temperatures throughout the California region as represented in the model of Snyder et al. (2002). The temperature increases of 1.4–3.8 degrees C throughout the region are consistent with global modeling projections. Panels B, E, and H represent changes in April snowpack, and show a statistically significant decrease in the Sierras. Panels C, F and I show April precipitation. Note the increase in the northern part of the State, and slight decrease in central California. Figure from Snyder et al. (2002).
Figure 2a. Hadley2 model temperature changes for 2080 showing increases of 2 to 5 degrees C for the western United States. [www.cics.uvic.ca/scenarios/index.cgi](http://www.cics.uvic.ca/scenarios/index.cgi)

Figure 2b. Hadley2 model precipitation changes for 2080, showing projected increases in precipitation in the western United States. [www.cics.uvic.ca/scenarios/index.cgi](http://www.cics.uvic.ca/scenarios/index.cgi)
Figure 2c. Canadian model 1 showing temperature changes across North America for 2080, including 3 to 7 degrees C temperature increases in the western United States. www.cics.uvic.ca/scenarios/index.cgi

Figure 2d. Canadian climate model precipitation changes for 2080 showing substantial precipitation increases in the western United States. www.cics.uvic.ca/scenarios/index.cgi
2.4. Evaporation and Transpiration

Evaporation and transpiration are important aspects of the hydrologic balance affecting climate, plant growth and distributions, and water demand and use. Increasing average temperatures generally lead to an increase in the potential for evaporation, though actual evaporation rates are constrained by the water availability on land and vegetation surfaces and in the soils. In California, atmospheric moisture content can limit evaporation rates, so changes in humidity are relatively important. Vegetative cover is also important because plants intercept precipitation and transpire water back to the atmosphere. Different vegetation types play different roles in evaporation; so evaluating the overall hydrologic impacts of climate change in a region requires some understanding of current vegetation patterns and of the ways in which vegetation patterns may change.

Transpiration, the movement of water through plants to the atmosphere, is affected by variables including plant cover, root depth, stomatal behavior, and the concentration of carbon dioxide (CO$_2$) in the atmosphere. Investigations of the impacts of increased carbon dioxide concentrations on transpiration have yielded conflicting results—some assessments suggest reductions in overall water use while others indicate that some plants acclimatize to increased CO$_2$ levels, limiting improvements in water-use efficiency (Field et al. 1995; Korner 1996; Rötter and Van de Geijn 1999). Multiple factors related to climate change can have more complex effects when taken together, including suppressing gains in plant growth (Shaw et al. 2002). Reproducible generalizations for evapotranspiration (ET) are not yet available, and these issues are central for future research.

Climate models have consistently projected that global average evaporation would increase in the range of 3 to 15 percent for an equivalent doubling of atmospheric carbon dioxide concentration. The greater the warming, the larger these increases are expected to be (IPCC 2001).

2.5. Snowpack

By delaying runoff from winter months when precipitation is greatest, snow accumulation in the Sierra Nevada acts as a massive natural reservoir for California. Despite uncertainties about how increased greenhouse gas concentrations may affect precipitation, there is very high confidence that higher temperatures will lead to dramatic changes in the snowfall and snowmelt dynamics in watersheds with substantial snow (see summary in Gleick and others 2000). Higher temperatures will have several major effects: they will increase the ratio of rain to snow, delay the onset of the snow season, accelerate the rate of spring snowmelt, and shorten the overall snowfall season, leading to more rapid and earlier seasonal runoff.

As early as the mid-1980s and early 1990s, regional hydrologic modeling of global warming impacts has suggested with increasing confidence that higher temperatures will affect the timing and magnitude of runoff in California (see, for example, Gleick 1986; Gleick 1987a,b; Lettenmaier and Gan 1990; Lettenmaier and Sheer 1991; Nash and Gleick 1991a,b; Hamlet and Lettenmaier 1999). Indeed, over the past two decades, this
has been one of the most persistent and well-established findings on the impacts of climate change for water resources in the United States and elsewhere, and it continues to be the major conclusion of regional water assessments (see, for example, Knowles and Cayan 2002; Barnett et al. in review). Figure 3 shows hypothetical changes in hydrographs that can be expected with changing snow dynamics in the Sierra Nevada. Figure 4 shows a specific projection of changes in Sierra Nevada snowpack from a regional modeling study.

Figure 3. Rising temperatures will reduce runoff in spring and summer and increase it during winter months by affecting snowfall patterns and the timing and rate of snowmelt. (from Gleick and others 2000).

A few broad assessments have simulated the effects of climate change on snowpack in the United States (McCabe and Legates 1995; Cayan 1996; McCabe and Wolock 1999). McCabe and Wolock (1999) evaluated the links between climate conditions and snowpack for over 300 different snow sites in the western United States, including the Sierra Nevada and the Colorado basin. They used long-term historical records to develop a snow model that used altered climatic information from GCMs. For most of the sites, strong positive correlations were found between precipitation and snowpack; strong negative correlations were found between temperature and snowpack. These correlations indicate that the supply of winter moisture is the best predictor of snowpack volume, while temperature is the best predictor of the timing of snowmelt and the overall nature of the snow season. This correlation breaks down only for those high-altitude sites where mean winter temperatures are so cold that the ratio of rain to snow is not affected.
The models used in the National Assessment (Gleick and others 2000) show large decreases in April 1 snowpack for all of the snow sites in California. In some of the extreme cases, model snowpack is completely eliminated by the end of the next century, although some snowfall and snowmelt would certainly continue in high-altitude sites. More recent work with a more detailed regional scale shows snow accumulation in February will be reduced by up to 82% in a 2xCO₂ scenario, with an almost complete melting by the end of April (Snyder et al. 2002). Figures 1 and 4 show other modeling efforts projecting that decreased snowfall and enhanced winter snowmelt could deplete most of the snow cover in California by the end of the winter (Kim et al. 2002; Knowles and Cayan 2002).

Figure 4. Possible snowpack changes from Knowles and Cayan (2002) for the Sierra Nevada, showing dramatic drops in snowpack liquid water content by the middle of this century for typical GCM projections of temperature increases. This dramatic graphic is a good illustration of the kinds of snowpack changes noted in a wide range of studies beginning in the early 1980s (see text for details).

2.6. Variability, Storms, and Extreme Events

Variability is a natural part of any climatic system, caused by processes that will continue to exert an important influence on the climate system even as changes induced by rising concentrations of greenhouse gases are felt. Efforts to understand how natural patterns of variability, such as hurricanes, intense rainstorms, and El Niño/La Niña events affect California’s water resources help to identify vulnerabilities of existing systems to hydrologic extremes (McCabe 1996; Vogel et al. 1997; Piechota et al. 1997; Cayan et al. 1999).
Large climatic variability has been a feature of California’s past. Paleoclimatic evidence from tree rings, buried stumps, and lakebed sediment cores suggests that the past 200 years has been relatively wet, and relatively constant when compared with longer records (Meko et al. 1980; Michaelsen et al. 1987; Hughes and Brown 1992; Earle 1993; Haston and Michaelsen 1997; Meko et al. 2001; Benson et al. 2002). These longer records reveal greater variability than the historical record, in particular in the form of severe and prolonged droughts (Stine 1994). In spite of this evidence, planning and operation are generally based on the historical climate record since 1900, which may not be representative of past or future conditions.

While variability is not well modeled in large-scale general circulation studies, some modeling studies suggest that the variability of the hydrologic cycle increases when mean precipitation increases, possibly accompanied by more intense local storms and changes in runoff patterns (Noda and Tokioka 1989; Kothavala 1997; Hennessy et al. 1997). In addition, another long-standing model result points to an increase in drought often resulting from a combination of increased temperature and evaporation along with decreased precipitation (Haywood et al. 1997; Wetherald and Manabe 1999; Meehl et al. 2000; Lambert 1995; Carnell and Senior 1998; Felzer and Heard 1999).

Models produce various pictures of increased storminess, but increased storm intensity is consistently forecast, whether or not their frequency also increases. (Carnell and Senior 1998; Hayden 1999; Lambert 1995; Frei et al. 1988).

The frequency of El Niño events may increase due to greenhouse warming. Timmermann et al. (1999) used a high-resolution global climate model to simulate the El Niño/Southern Oscillation (ENSO) phenomenon under conditions of warming. Their model indicated that the tropical Pacific climate system would undergo systematic changes if greenhouse gas concentrations doubled. In particular, their results suggest a world where the average condition would be like the present-day El Niño condition and events typical of El Niño would become more frequent. Their results also found more intense La Niña events and stronger interannual variability, meaning that year-to-year variations may become more extreme under enhanced greenhouse conditions. More frequent or intense El Niños would alter precipitation and flooding patterns in the United States in a significant way.

In a study that analyzed 20 GCMs currently in use worldwide, extreme events may intensify over the next century as CO₂ and other greenhouse gases increase in the atmosphere. The study suggests that the West Coast may be less affected by extreme droughts than other areas, instead having increased rainfall resulting in moister soil (Meehl et al. 2000). However, in a study that reviewed several GCM scenarios, an increased risk of large storms and flood events was shown for California (Miller et al. 1999). Conflicting conclusions about storms support the need for higher-spatial-resolution models with better cloud and precipitation processes.

Increased storminess could have implications for flooding. In modeling by DWR on the American River basin, increased storm temperatures of three degrees Celsius increased storm runoff by about 10 percent (personal communication, M. Roos 2003). The 1986 flood on which these experiments were based had the highest 3-day average flow on
record for the American River, claimed fifteen lives, and caused more than a billion dollars in property damage (www.news.water.ca.gov/1997.spring/quest.html). Any increase in large flood events could result in a need for significant changes in operating rules, floodplain management approaches, or even investment in new infrastructure.

2.7. Large-Area Runoff

Runoff is directly affected by changes in precipitation and temperature. However, runoff in actual watersheds is rarely explicitly evaluated in GCMs, because their resolution is insufficient to include other critical watershed characteristics. Estimates of changes in runoff over large areas are thus often relatively simple evaluations of changes in large-scale precipitation and evapotranspiration patterns (Arnold et al. 1998; Arnold et al. 1999; Srinivasan et al. 1993). Despite remaining uncertainties in precipitation patterns, especially, Brown et al. (1999) concluded that the potential impact of altered precipitation and the expected increases in evapotranspiration are of large enough dimensions to require consideration in any analysis of future regional or national water supply and demand. Another important consideration is the projected change in seasonality of the hydrologic cycle that would affect the heavily managed water systems of the western United States.

In California, water yields will increase in late winter/early spring because of increased runoff, as described earlier, due to the seasonality of the precipitation changes and to an earlier spring snowmelt caused by the projected warming under climate change. Rising temperatures also impact annual water yields by increasing ET, thereby reducing the contribution of lateral flow to streamflow and groundwater recharge. This combination results in a marked increase in water yield during late winter and early spring and in some cases a reduction in water yield during the summer. If there is no general increase in precipitation in these regions, the early snowmelt will lead to shortages of water in summer. The hydrology is controlled by the timing and intensity of the spring snowmelt, and is impacted principally by the degree of warming during this time period.

Several different conclusions can be drawn from a review of the literature. First, the great differences in results show the difficulty of making accurate “predictions” of future runoff—these results should be viewed as sensitivity studies and used with considerable caution. Second, runoff is extremely sensitive to climate conditions. Large increases in precipitation will probably lead to increases in runoff: such increases can either worsen or lessen water management problems, depending on the region and the nature of the problem. Third, far more work is needed, on a finer scale, to understand how climate will affect national water resources. Until GCMs get better at evaluating regional temperature and precipitation, their regional estimates of future runoff must be considered speculative and uncertain. While it is well established that changes in runoff are likely to occur, we have little confidence that we understand how specific regions will be affected. The above discussion and model results highlight many of the uncertainties surrounding the implications of climate change for overall water availability.
2.8. Regional Runoff

Detailed estimates of changes in runoff due to climate change have been produced for California using regional hydrologic models. By using anticipated, hypothetical, or historical changes in temperature and precipitation and models that include realistic small-scale hydrology, modelers have consistently seen significant changes in the timing and magnitude of runoff resulting from quite plausible changes in climatic variables. In California, runoff is extremely sensitive to rainfall: a small percentage change in rainfall can produce a much larger percentage change in runoff. Considerable effort has been made to evaluate climate impacts in particular river basins, including the Sacramento, the San Joaquin, the Colorado, the Carson/Truckee, and others. Even in the absence of changes in precipitation patterns, higher temperatures resulting from increased greenhouse gas concentrations lead to higher evaporation rates, reductions in streamflow, and increased frequency of droughts (Schaake 1990; Rind et al. 1990; Nash and Gleick 1991a,b, 1993). In such cases, increases in precipitation would be required to maintain runoff at historical levels.

For California, one of the most important results for planners has also been one of the most consistent. Warming-induced change in the timing of streamflow, including both the intensity and timing of peak flows, is a consistent result. A declining proportion of total precipitation falls as snow as temperatures rise, more winter runoff occurs, and remaining snow melts sooner and faster in spring (see, for example, Gleick 1986, 1987a,b; Lettenmaier and Gan 1990; Nash and Gleick 1991b; Miller et al. 1999; Knowles and Cayan 2002; VanRheenen et al. in press). In some basins, spring peak runoff may increase; in others, runoff volumes may significantly shift to winter months.

Shifts in runoff timing in snowmelt-fed basins are consistent in all studies that looked at daily or monthly runoff. These studies show with very high confidence that increases in winter runoff, decreases in spring and summer runoff, and higher peak flows will occur in such basins as temperatures - and hence both snowline and melt rates - rise.

Assuming the amount of precipitation remained approximately the same, in the Sacramento River region, only about one fourth of the snow zone would remain, with an estimated decrease of 5 million acre feet (MAF) of April through July runoff (Cayan 1996; Knowles and Cayan 2002; Miller et al. 1999. The impact would be much less in the higher elevation of southern Sierra. For example in the San Joaquin/Tulare Lake region about seven-tenths of snow zone would remain.

Under current operating rules, less spring snowmelt could also make it more difficult to refill winter reservoir flood control space during late spring and early summer of many years, thus potentially reducing the amount of surface water available during the dry season. Lower early summer reservoir levels also would adversely affect lake recreation and hydroelectric power production, with possible late-season temperature problems for downstream fisheries.
2.9. Colorado River

The Colorado River supplies water to nearly 30 million people and irrigates more than one and a half million hectares of farmland in Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, California, and the Republic of Mexico. Spanning 2,300 kilometers and eventually running through Mexico to the Sea of Cortez, the river is the only major water supply for much of the arid southwestern United States and the Mexicali Valley of Mexico, and it plays a special role in California's water situation.

Colorado River basin water supply, hydroelectricity generation, reservoir levels, and salinity are all sensitive to both the kinds of climate changes that are expected to occur and to the policy options chosen to respond to them. Because of concerns about these issues, some of the very first river basin climate studies examined the impacts of climatic changes on the Colorado River basin and several of its major tributaries.

The earliest studies used historical regression approaches to evaluate the impacts of hypothetical temperature and precipitation changes (Stockton and Boggess 1979; Revelle and Waggoner 1983). Both of these studies suggested that modest changes in average climatic conditions could lead to significant changes in runoff. Revelle and Waggoner concluded that a 2 degree Celsius (C) increase in temperature with a 10-percent drop in precipitation would reduce runoff by 40 percent. Stockton and Boggess’ results were similar, with a projected 35 to 56 percent drop in runoff.

By the late 1980s, researchers began to use physically based models capable of evaluating climatic conditions outside of the range of existing experience and hydrologic statistics. Under the auspices of the American Association for the Advancement of Science (AAAS), Schaake (1990) used a simple water-balance model to evaluate the elasticity of runoff in the Animas River in the upper Colorado River basin. That study suggested that a 10-percent change in precipitation would lead to a 20-percent change in runoff, while a 2 degree C increase in temperature would reduce runoff by only about 2 percent. More significant, however, was the finding that changes in temperature would have significant seasonal effects on snowmelt, a finding in agreement with the earlier conclusions of Gleick (1987) for the Sacramento River (described elsewhere).

In 1991, the U.S. Bureau of Reclamation (which has responsibility for operations in the Colorado Basin) and the U.S. Geological Survey evaluated the impacts of global climate change on the Gunnison Basin, an important tributary of the Colorado. Like the earlier Schaake study, this analysis also found significant seasonal changes in runoff due to increases in temperature, with an advance in spring snowmelt of close to a month for a temperature increase of 2 to 4 degrees C (Dennis 1991).

Nash and Gleick (1991a,b, 1993) analyzed the impacts of climate change on the Colorado basin using conceptual hydrologic models coupled with the U.S. Bureau of Reclamation Colorado River Simulation System (CRSS) model of the entire water-supply system of the river (Nash and Gleick 1991a,b, 1993). They evaluated hypothetical temperature and precipitation scenarios as well as the equilibrium GCM scenarios available at the time. A GCM transient run was done as well with one of the first models to use transient greenhouse gas inputs. River flows were found to be very sensitive to both precipitation and temperature, though less sensitive than the earlier regression studies. As with
earlier studies, major changes in the seasonality of runoff resulted from the impacts of higher temperature on snowfall and snowmelt dynamics. The effects of climate changes on water supplies were dependent on the operating characteristics of the reservoir system and the institutional and legal rules constraining the operators. The variables most sensitive to changes in runoff were found to be salinity, hydroelectric generation, and reservoir level. This study also evaluated the possible utility of increased storage capacity to address the impacts of climate changes and concluded that additional storage would do nothing to alleviate potential reductions in flow. Only if climatic changes were to increase streamflow variability without decreasing long-term supply might additional reservoirs in the Upper Colorado River Basin have any benefits.

Another comprehensive assessment of the Colorado Basin’s systems of reservoirs was done for the Colorado River Severe Sustained Drought study (CRSSD) (Lord et al. 1995). That analysis focused on a scenario of long-term drought, rather than a single climate change scenario, and concluded that the “Law of the River” as currently implemented would leave ecosystems, hydropower generation, recreational users, and Upper Basin water users vulnerable to damages, despite the extensive infrastructure. A related study also found that water reallocation through marketing had the power to reduce drought damages (Booker 1995).

Eddy (1996) looked at extreme events in the Colorado Basin and evaluated the impact of an increase or decrease in precipitation of 10 percent on the duration of wet and dry periods. Eddy concluded that changing average precipitation would not change the number of consecutive wet or dry years by more than one year, but that about once every 20 years, some groupings of stations would experience a dramatic change in consecutive extreme years. If several portions of the Upper Colorado Basin experienced these major wet or dry periods simultaneously, “an episode of crisis proportions could occur.” Recently, Christensen et al. (2002) have updated this work on the Colorado River basin and found comparable changes in snowfall/snowmelt dynamics, runoff, and sensitivity of the water resource system in the basin to climate change.

2.10. Soil Moisture

Soil moisture—a measure of the water in different depths of soil—defines vegetation type and extent, influences agricultural productivity, and affects groundwater recharge rates. The amount of water stored in the soils is influenced by vegetation type, soil type, evaporation rates, and precipitation intensity. Any changes in precipitation patterns and evapotranspiration regime directly affect soil-moisture storage. Decreased precipitation or increased temperature can each lead to decreases in soil moisture. Where precipitation increases significantly, soil moisture is likely to increase, perhaps by large amounts.

GCM results suggest large-scale regional soil drying in summer owing to higher temperatures. Drying could have significant impacts on agricultural production and on the supply of and demand for water. One consequence of this drying is an expected increased incidence of droughts in some regions, measured by soil-moisture conditions, even where precipitation increases, because of the increased evaporation (Vinnikov et al.
1996). Soil-moisture response has important implications for crop yield and irrigation demand (Brumbelow and Georgakakos 2000).

Modeling of the Sacramento Basin identified reductions in summer soil moisture of 30 percent or more resulting from a shift in the timing of runoff from spring to winter, a decrease in snow, and higher summer temperatures and evaporative losses (Gleick 1986, 1987a,b). Similar results are seen for the Colorado River basin, where large increases in precipitation were found to be necessary in order to simply maintain soil moisture at present historical levels as temperatures and evaporative losses rise (Nash and Gleick 1991b, 1993).

2.11. Water Quality

Water quality depends on a wide range of variables, including water temperatures, flows, runoff rates and timing, and the ability of watersheds to assimilate wastes and pollutants. Climate change could alter all of these variables. Higher winter flows of water could reduce pollutant concentrations or increase erosion of land surfaces and stream channels, leading to higher sediment, chemical, and nutrient loads in rivers. Changes in storm flows will affect urban runoff, with attendant water-quality impacts. Lower summer flows could reduce dissolved oxygen concentrations, reduce the dilution of pollutants, and increase zones with high temperatures. Less directly, changes in land use resulting from climatic changes, together with technical and regulatory actions to protect water quality, can be critical to future water conditions. The net effect on water quality for rivers, lakes, and groundwater in the future therefore depends not just on how climatic conditions might change but also on a wide range of other human actions and management decisions, as noted in modeling experiments by Eheart et al. (1999).

In a review of potential impacts of climate change on water quality, Murdoch et al. (2000) conclude that significant changes in water quality are known to occur as a direct result of short-term changes in climate. They note that water quality in ecological transition zones and areas of natural climate extremes is vulnerable to climate changes that increase temperatures or change the variability of precipitation and argue that changes in land and resource use will have comparable or even greater impacts on water quality than changes in temperature and precipitation. They recommend that long-term monitoring of water quality is critical for identifying severe impacts, as is developing appropriate management strategies for protecting water quality.

Moore et al. (1997) note that increased water temperatures enhance the toxicity of metals in aquatic ecosystems and that increased lengths of biological activity could lead to increased accumulation of toxics in organisms. Ironically, increased bioaccumulation could decrease the concentration of toxics in the water column, improving local water quality. Similarly, higher temperatures may lead to increased transfer of chemicals from the water column to sediments. However, increases in air temperature, and the associated increases in water temperature, are likely to lead to adverse changes in water quality, even in the absence of changes in precipitation.

Ecosystems influence water quality in very direct ways. Changes in terrestrial ecosystems will also lead to changes in water quality by altering nutrient cycling rates
and the delivery of nutrients to surface waters (Murdoch et al. 1998). The issues of water quality and ecosystem health should be weighed together (see below).

Studies suggest that changes in precipitation will affect water quantity, flow rates, and flow timing. Decreased flows can exacerbate temperature increases, increase the concentration of pollutants, increase flushing times, and increase salinity (Schindler 1997; Mulholland et al. 1997). Decreased surface-water volumes can increase sedimentation, concentrate pollutants, and reduce non-point source runoff (Mulholland et al. 1997). Increases in water flows can dilute point-source pollutants, increase loadings from non-point source pollutants, decrease chemical reactions in streams and lakes, reduce the flushing time for contaminants, and increase export of pollutants to coastal wetlands and deltas (Jacoby 1990; Mulholland et al. 1997; Schindler 1997). Higher flows can increase turbidity in lakes, reducing ultraviolet-B (UV-B) penetration. More work specific to California needs to be done.

### 2.12. Lake Levels and Conditions

Although little California-specific work has been done, lakes are known to be sensitive to a wide array of changes in climatic conditions. Variations in temperature, precipitation, humidity, and wind conditions can alter evaporation rates, the water balance of a basin, ice formation and melting, and chemical and biological regimes (McCormick 1990; Croley 1990; Bates et al. 1993; Hauer et al. 1997; Covich et al. 1997; Grimm et al. 1997; Melak et al. 1997). Closed (endorheic) lakes are extremely sensitive to the balance of inflows and evaporative losses. Even small changes in climate can produce large changes in lake levels and salinity (Laird et al. 1996).

Other effects of increased temperature on lakes could include higher thermal stress for cold-water fish, higher trophic states leading to increased productivity and lower dissolved oxygen, degraded water quality, and increased summer anoxia. Decreases in lake levels coupled with decreased flows from runoff and groundwater may exacerbate temperature increases and loss of thermal refugia and dissolved oxygen. Increased net evaporation may increase salinity of lakes. Hostetler and Small (1999) also note that climate variability may amplify or offset changes in the mean state under climate changes and may ultimately be more important that changes in average conditions. Some non-linear or threshold events may also occur, such as a fall in lake level that cuts off outflows or separates a lake into two isolated parts. Work is needed to identify threatened lakes in California and projected impacts of such events on downstream flows and groundwater recharge.

### 2.13. Groundwater

Groundwater withdrawals in California in the mid-1990s are estimated to be around 14.5 million acre-feet, nearly 20 percent of all the groundwater withdrawn in the entire United States. (In typical years, groundwater accounts for around 30 percent of all urban and agricultural water use in the state (www.groundwater.water.ca.gov/). In some areas current levels of groundwater use are already unsustainable, with pumping rates exceeding natural recharge. Groundwater overdrafts in California in the drier years of
the 1990s averaged nearly 1.5 million acre-feet per year (www.groundwater.water.ca.gov/).

Little work has been done on the impacts of climate changes for specific groundwater basins, or for general groundwater recharge characteristics or water quality. Changes in recharge will result from changes in effective rainfall as well as a change in the timing of the recharge season. Increased winter rainfall, expected for some mid-continental, mid-latitude regions could lead to increased groundwater recharge. Higher temperatures could increase the period of infiltration where soils freeze. Higher evaporation or shorter rainfall seasons, on the other hand, could mean that soil deficits persist for longer periods of time, shortening recharge seasons (Leonard et al. 1999). A significant portion of winter recharge comes from deep percolation of precipitation below the rooting zone, whether of native vegetation or farmland. Warmer winter temperatures between storms would be expected to increase ET, thereby drying out the soil between storms. A greater amount of rain in subsequent storms would then be required to wet the root zone and provide water for deep percolation.

Pumping from some coastal aquifers in California has exceeded the rates of natural recharge, resulting in saltwater intrusion into the aquifers. Sea-level rise could also affect coastal aquifers through saltwater intrusion. Oberdorfer (1996) used a simple water-balance model to test how changes in recharge rates and sea-level would affect groundwater stocks and flows in a California coastal watershed. While some sensitivities were identified, the author notes that the complexity of the interactions among the variables required more sophisticated analysis.

Warmer, wetter winters would increase the amount of runoff available for groundwater recharge. However, this additional runoff in the winter would be occurring at a time when some basins, particularly in Northern California, are either being recharged at their maximum capacity or are already full. Conversely, reductions in spring runoff and higher evapotranspiration because of higher temperatures could reduce the amount of water available for recharge. The extent to which climate will change and the impact of that change are both unknown. A reduced snowpack, coupled with increased rainfall may require a change in the operating procedures for our existing dams and conveyance facilities.

The most recent California groundwater report from the Department of Water Resources notes that these possible changes may require more sophisticated conjunctive management programs in which the aquifers are more effectively used as storage facilities. They also recommend that water managers consider evaluating their systems to better understand the existing snowpack-surface water-groundwater relationship, and identify opportunities that may exist to optimize groundwater storage capability under new hydrologic regimes that may result from climate change (www.groundwater.water.ca.gov/).

2.14. Sea Level

Sea-level rise, caused by thermal expansion of ocean waters and melting of ice from land surfaces, will affect groundwater aquifers and coastal ecosystems. Mean sea level (msl)
data for stations along the coast of California show msl rising. Figures 5a and b show the increase as measured at Fort Point/the Golden Gate in San Francisco over the past 100 years. Early studies of the impacts of sea-level rise in California show that estuarine impacts of sea-level rise will be felt in the San Francisco Bay and the Sacramento-San Joaquin River delta in northern California (Williams 1985, 1987; SFB CDC 1988). Among the risks will be threats to levee integrity and tidal marshes, the salinity of water in the Delta region, and intrusion of salt water into coastal aquifers.

Delta levees protect transportation systems, agriculture, and homes in the region. Williams projected that levees would fail at a higher rate, sediment movements would be changed, mudflats and salt marshes would experience more erosion, and ecosystem impacts could be substantial (Williams 1985, 1987). In addition, tidal marshes in parts of the San Francisco Bay would be submerged by a one-meter sea-level rise (SFB CDC 1988). One analysis showed that only a 15-centimeter (6 inch) rise would transform the current 100-year high tide peak in San Francisco Bay into about a 10-year event (Gleick and Maurer 1990). Severe high tides could thus become a more frequent threat to the delta levees and their ability to protect land and water systems there.

Williams (1985, 1987) also concluded that the average salinity level could migrate roughly 15 kilometers upstream, impacting the State’s water-supply infrastructure. This could degrade fresh water transfer supplies pumped at the southern edge of the Delta or require more fresh water releases to repel ocean salinity. Salinity is already a problem in the Delta. Both the Central Valley Project and the State Water Project are operated under water quality constraints. Most of the time, salinity constrains the project operations in late summer and early fall when the availability of water in the reservoirs are at its lowest. Therefore, to mitigate an increase in salinity due to sea level rise, pumping has to be cut during these months. The project operations are further constrained by X2 standards in months of February through June. (X2 is the distance in kilometers of tidally and depth-averaged 2 psu isohaline from the Golden Gate bridge.) More reservoir releases or reduced pumping would be required to push the increased salinity intrusion caused by the sea level rise back towards the bridge.

Earlier snowmelt runoff in the spring would allow more time for summer saltwater intrusion. Preliminary modeling studies indicate that increase in sea level and changes in freshwater inflows would affect salinity throughout the Sacramento-San Joaquin Delta (see, for example, Knowles and Cayan 2002).
2.15. Ecosystems

Humans are dependent upon ecosystem processes to supply essential goods and services such as primary productivity and inputs from watersheds, fish for commercial and recreational purposes, decomposition and biological uptake, and water purification. The health and dynamics of ecosystems are fundamentally dependent on a wide range of climate-sensitive factors, including the timing of water availability, and overall water quantity, quality, and temperature. All of these factors may be altered in a changed climate. Freshwater systems are rich in biological diversity, and a large part of the fauna is threatened in California—150 species of animals are listed as endangered or threatened under state and federal law, and more than 200 species of plants are facing similar threats (www.dfg.ca.gov/hcpb/species/t_e_spp/tespp.shtml). A changing climate may intensify these threats in many ways, such as by accelerating the spread of exotic species and further fragmenting populations (Firth and Fisher 1992; Naiman 1992). Experience with ecosystem dynamics strongly suggests that perturbing ecosystems in any direction away from the conditions under which they developed and thrive will have adverse impacts on the health of that system (Peters and Lovejoy 1992; IPCC 2001).

The direct effects of climate change on ecosystems will be complex. Previous assessments have established a wide range of possible direct effects, including changes in lake and stream temperatures, lake levels, mixing regimes, water residence times, water clarity, thermocline depth and productivity, invasions of exotic species, fire
frequency, permafrost melting, altered nutrient exchanges, food web structure, and more (for a review, see Gleick and others 2000; Wilkinson and others 2002).

The ecological response to a modification in natural flow regime resulting from climate change depends on how the regime is altered relative to the historical conditions (Meyer et al. 1999). For example, a system that has historically experienced predictable, seasonal flooding, such as snowmelt-dominated streams and rivers, may show dramatic changes in community composition and ecosystem function if the seasonal cycles are eliminated or substantially altered, as has been documented for the loss of riparian trees along western watercourses (Auble et al. 1994).

It is likely that the ecosystems at greatest risk from climate change are those that are already near important thresholds, such as where competition for water is occurring, where water temperatures are already near limits for a species of concern, or where climate change will act with other anthropogenic stressors such as large water withdrawals or wastewater returns (Meyer et al. 1999; Murdoch et al. 2000).

There will be both positive and negative direct effects of increasing temperatures on aquatic and terrestrial ecosystems. In general, while many uncertainties remain, ecologists have high confidence that climatic warming will produce a northward shift in species distributions, with extinctions and extirpations of temperate or cold-water species at lower latitudes, and range expansion of warm-water and cool-water species into higher latitudes (Murdoch et al. 2000).

Nutrient loading generally increases with runoff, particularly in human-dominated landscapes (Alexander et al. 1996). Delivery of constituents like phosphorus, pesticides, or acids in pulses can have adverse consequences for fishes. Increased numbers of water-quality excursions that exceed ecological thresholds will limit the effectiveness of policies designed for average conditions (Murdoch et al. 2000).


Burkett and Kusler (2000) reviewed likely climate change impacts on wetlands. They concluded that expected changes in temperature and precipitation would alter wetland hydrology, biogeochemistry, plant species composition, and biomass accumulation. Because of fragmentation resulting from past human activities, wetland plants often cannot migrate in response to temperature and water-level changes, and hence, are vulnerable to complete elimination. Wetland plant response to increased CO₂ could also lead to shifts in community structure with impacts at higher trophic levels. Small changes in the balance between precipitation and evapotranspiration can alter groundwater level by a few centimeters, which can significantly reduce the size of wetlands and shift wetland types. Burkett and Kusler (2000) note that there are no practical options for protecting wetlands as a whole from rising temperature and sea level and changes in precipitation. Some management measures could be applied to
specific places to increase ecosystem resilience or to partially compensate for negative impacts, but there is often no explicit economic or institutional support for doing so. Among the options for mitigation are development setbacks for coastal and estuarine wetlands, linking fragmented ecosystems to provide plant and animal migration routes, using water-control structures to enhance ecosystem function, and explicit protection and allocation of water needed for ecosystem health. Some research has been done on these issues, but far more is needed, including modeling and experimental work on the interactions with food webs and hydrological regimes (Power et al. 1995; Carpenter et al. 2000).

Increased concentrations of greenhouse gases has been observed to both either increase and decrease plant growth, depending on species and the availability of other key growth conditions (Field et al. 1995). Availability of water at a critical time of the plant life will determine actual plant growth. Predicted drier summers might adversely affect drought-sensitive plants. Further research has to be done in translating possible increase plant growth to increase in yield.

2.16. Water Demand
Both human and environmental water demand, and overall water supply, will be affected by expected climatic changes. For example, as temperatures rise, plant evapotranspiration often goes up, though this is also affected by overall carbon dioxide concentrations. Some research suggests higher CO2 levels can reduce water use in some crops, at least in the short run. The net effect, especially on agricultural crops, is still uncertain (see Korner 2000, and also Shaw et al. 2003). Similarly, water needs by natural vegetation will change as climate changes, affecting runoff and recharge rates, as well as plant survival and transition. The area of plant evapotranspiration and overall water use remains an important area of ongoing research.

3.0 Is Climate Change Already Affecting California’s Water?
3.1. Temperature and Related Trends
The average surface temperature of the Earth has increased by around 0.6 degrees Celsius over the past century (NRC 2000). The fifteen warmest years this century have all occurred since 1980 and, the 1990s were the warmest decade of the entire millennium (Mann and Bradley 1999). Temperatures in the United States have also increased. Pronounced warming has occurred in winter and spring, with the largest increases in the period March–May over the western U.S. (Lettenmaier et al 1994; Dettinger and Cayan 1995; Vincent et al. 1999). Figures 6 and 7 show global and hemispheric temperature trends.
Figure 6. Global temperatures have been rising sharply in the northern hemisphere since the industrial revolution. This graph shows Northern Hemisphere temperature reconstruction from paleoclimate data (blue) and instrumental data (red) from AD 1000 to 1999, adapted from Mann et al. (1999). Smoother version of NH series (black), linear trend from AD 1000 to 1850 (purple-dashed) and two standard error limits (grey shaded) are shown.

Temperature trends (1900–94 in °C per Century)
Figure 7. Temperature Trends in the Continental United States (1900 to 1994).

3.2. Precipitation Trends
Karl and Knight (1998), updated by Groisman et al. (2001) show an increase in precipitation in the continental United States, with most of the increase in the highest annual one-day precipitation event—a potentially worrisome trend in regions where flooding is a problem (Figure 8). By analyzing long-term precipitation trends in the United States, they determined that:

- Precipitation over the contiguous United States has increased by about 10 percent since 1910;
- The intensity of precipitation has only increased for very heavy and extreme precipitation days;
- Increases in total precipitation are strongly affected by increases in both the frequency and the intensity of heavy and extreme events, measured as the highest 1-day annual precipitation event;
- The probability of precipitation on any given day has increased;
- The proportion of total precipitation from heavy events has increased at the expense of moderate precipitation events.
3.3. Runoff Trends

River runoff or discharge reflects multiple climatic factors, which makes it an important indicator of climatic variability and change. Discharge also integrates numerous human influences such as flow diversions for irrigation and municipal use, natural streamflow regulation by dams and reservoirs, and baseflow reduction by groundwater pumping. Detecting a climate signal in the midst of these complicating factors can be difficult (Changnon and Demissie 1996) and this is one of the most active areas for ongoing research.

Shortly after early modeling studies projected changes in the timing of runoff with increasing temperatures (Gleick 1986, 1987b), DWR hydrologist Maurice Roos provided empirical evidence consistent with these projections (Roos 1987). In recent years, these changes in timing of streamflow have gained in statistical significance (shown in Figure 9).

![Sacramento River Runoff](image)

**Figure 9.** Historical trend in seasonal runoff for the Sacramento River. The decreasing percentage of April–July runoff indicates an earlier melting of the seasonal mountain snowpack.
Lins and Slack (1999) looked at historical trends in monthly mean flow across broad regions of the U.S., finding statistically significant increases in California. Lettenmaier et al. (1994) evaluated trends using monthly mean discharge and also found significant increases in western streamflow from 1948 through 1988. During 1948 through 1991, snowmelt-generated runoff came increasingly early in the water year in many basins in northern and central California. A declining fraction of the annual runoff was occurring during April to June in middle-elevation basins (as described above) and an increasing fraction was occurring earlier in the water year, particularly in March (Dettinger and Cayan 1995). Gleick and Chalecki (1999) observed this same basic pattern in an analysis of the Sacramento and San Joaquin Rivers over the entire twentieth century.

Groisman et al. (2001) found little relation between increases in heavy precipitation and changes in high streamflow, similar to Lins and Slack (1999). More recently, however, Groisman et al. (2001) have documented an increase in precipitation and especially heavy precipitation in the United States as a whole, and related changes in peak streamflow. The changes were most notable in the eastern United States because changes in snowcover in the West have complicated runoff studies. In the mountainous western US, snow cover has significantly retreated during the latter half of the twentieth century, and there have been related shifts in seasonal discharges, but peak flows have not increased because of the changes in timing.

Snowmelt-runoff timing shifts, especially in middle-elevation mountainous river basins are important because of their sensitivity to changes in mean winter temperatures (Dettinger and Cayan 1995). However, as Dettinger and Cayan further note, the observed hydrologic shifts in these areas can involve more than simple relationships with air temperature alone.

Climate models and theoretical studies of snow dynamics have long projected that higher temperatures would lead to a decrease in the extent of snow cover in the Northern Hemisphere (see, for example, Dettinger and Cayan 1995; Cayan 1996). Recent field surveys corroborate these findings. Snow cover over the Northern Hemisphere land surface has been consistently below the 21-year average (1974 to 1994) since 1988 (Robinson et al. 1993; Groisman et al. 1994), with an annual mean decrease in snow cover of about 10 percent over North America.

3.4. Variability and Extreme Events

Extreme weather events are expected to be one of the most significant impacts of climate change. Phenomena such as the El Niño/Southern Oscillation, which is the strongest natural interannual climate fluctuation, have effects on the entire global climate system and the economies and societies of many regions and nations, including the United States. The strong El Niños of 1982/83 and 1997/98, along with the more frequent occurrences of El Niños in the past few decades, have forced researchers to try to better understand how human-induced climate change may affect interannual climate variability (Trenberth and Hoar 1996; Timmermann et al. 1999).

Analyses of flood risks are traditionally based on past data and on a fundamental assumption that peak floods are “random, independent, and identically distributed
events.” This assumes that climatic trends or cycles are not affecting the distribution of flood flows and that the future climate will be similar to past climate. Current concern over natural variability, anthropogenic climate change, and possible impacts on hydrology, however, calls this assumption into question (NRC 1998).

4.0 Climate Change and Impacts on Managed Water-Resource Systems

There is a rapidly growing literature about how climate changes may affect U.S. water resources systems (see www.pacinst.org/resources for a searchable bibliography). Research has been conducted on a wide range of water-system characteristics, including reservoir operations, water quality, hydroelectric generation, and others. At the same time, significant gaps remain.

The Central Valley Project and the State Water Project are each operated under strict guidelines, with constraints that have to be met prior to water being available for export. Flood control storage in reservoirs, water rights in upper Sacramento and San Joaquin, minimum flow requirements in the rivers and the Delta, dissolved oxygen concentration in the Stanislaus River, 800,000 acre-feet per year reserved for restoration of fish, wildlife and habitat restoration and salinity standards in the Delta are all considered in pumping operations. Even under existing supply and demand patterns, water requirements are barely met under dry and critical water years. Modifying existing constraints and optimizing the current operation of the system should be looked into, especially because of the possibility of a reduced water supply at critical times due to climate change.

Precipitation, temperature, and carbon dioxide levels affect both the supply of, and demand for, renewable water resources. Agricultural, urban, industrial and environmental needs will each increase at certain times of the year. For example, irrigation is particularly sensitive to climatic conditions during the growing season. Also, while indoor domestic water use is not very sensitive to temperature and precipitation, outdoor uses for gardens and parks are very climate dependent. And, higher water temperatures would reduce the efficiency of cooling systems and increase the demand for cooling water. Thus, climate will affect overall water use directly and indirectly.

4.1. Water Supply Infrastructure

A major challenge facing hydrologists and water managers is to evaluate how changes in system reliability resulting from climate changes may differ from those anticipated from natural variability and, in theory, already anticipated in original project designs. Both surface and groundwater supply systems are known to be sensitive to the kinds of changes in inflows and demands described earlier. Many regional studies have shown large changes in the reliability of water yields from reservoirs could result from small changes in inflows (Nemec and Schaake 1982; USEPA 1989; Lettenmaier and Sheer 1991; McMahon et al. 1989; Cole et al. 1991; Mimikou 1991a,b; Mimikou and Kouvopoulos 1991; Nash and Gleick 1991b, 1993). Lettenmaier and Sheer (1991), for example, noted the sensitivity of the California State Water Project to climate change under current operating rules. They concluded that changes in operating rules might improve the ability of the system to meet delivery requirements, but only at the expense of an
increased risk of flooding. This kind of trade-off is now being seen in a broader set of analyses.

Changes in runoff were the most important factors determining the climate sensitivity of system performance (Lettenmaier et al. 1999), even when they evaluated the direct effects of climate change on water demands. These sensitivities depended on the purposes for which water was needed and the priority given to those uses. Higher temperatures increased system use in many basins, but these increases tended to be modest, as were the effects of higher temperatures on system reliability.

4.2. Hydropower and Thermal Power Generation

California produces hydropower at a rate second only to the Pacific Northwest. The amount of hydropower production for a given facility is function of amount of water available, head over which the water falls, and time of operation. Changes in precipitation amount or pattern will have a direct impact on hydropower generation. If snowpack decreases, hydropower generation during these months would be reduced. However, wetter winters might enable additional hydropower generation during winter and spring if adequate flood control can be provided.

Variability in climate already causes variations in hydroelectric generation. During a recent multi-year drought in California, decreased hydropower generation led to increases in fossil-fuel combustion and higher costs to consumers. Between 1987 and 1991, these changes cost ratepayers more than $3 billion and increased greenhouse gas emissions (Gleick and Nash 1991). Because of conflicts between flood-control functions and hydropower objectives, human-induced climate changes in California may require more water to be released from California reservoirs in spring to avoid flooding. This would result in a reduction in hydropower generation and the economic value of that generation. At the same time, production of power by fossil fuels would have to increase to meet the same energy demands in California, at a cost of hundreds of millions of dollars and an increase in emissions of greenhouse gases (Hanemann and McCann 1993).

Climate changes that reduce overall water availability or change the timing of that availability have the potential to adversely affect the productivity of U.S. hydroelectric facilities. In contrast, reliable increases in average flows would increase hydropower production. More sophisticated studies such as that by Lettenmaier et al. (1999) are necessary for California. Alternative sources of energy, combined with energy conservation, may be a necessary means of adapting to decreased hydropower.

4.3. Agriculture

The strong links between water-resources availability and use and agricultural productivity deserve some comment here. In particular, relatively small changes in water availability could lead to relatively large impacts in the agricultural sector. Assessing the impacts of climate change on agriculture requires integrating a wide range of factors.
In the mid-1990s, approximately 75 percent of all water consumption occurred in California’s agricultural sector. In California, the vast majority of agricultural production requires irrigation water from both surface and groundwater sources. Increases in water availability due to climate changes could help reduce the pressures faced by growers; conversely decreases in water availability are likely to affect growers more than other users for two reasons: urban and industrial users can pay more for water; and proportional reductions in water availability would lead to larger overall reductions to farmers. If irrigators holding senior water rights are allowed to sell or transfer those rights, some could actually benefit from decreases in water availability (Gleick and others 2000).

Brumbelow and Georgakakos (2000) assessed changes in irrigation demands and crop yields using physiologically based crop models, and reached several important conclusions for regional agricultural changes, though their results are dependent upon a single climate scenario and hence should be considered speculative. Durum wheat irrigation needs decreased significantly in California (82% decrease). Corn irrigation demands strongly decreased west of the 104th meridian (40% to 75% decrease) and were otherwise only slightly changed. In all regions, the length of the overall growing season increased. Economics of crop changes and quantitative water use figures are subjects for future research.

4.4. Extreme Events

Much of the analysis of climate and water impacts looks at how changes in various means will affect water and water systems, such as mean temperatures, average precipitation patterns, mean sea level, and so on. Although many factors of concern are affected by such average conditions, some of the most important impacts will result not from changes in averages, but from changes in local extremes. Water managers and planners are especially interested in extreme events and how they may change with climate change. Unfortunately, this is one of the least-well understood categories of impacts and we urge more effort be devoted to studying it. Hydrological fluctuations impose two types of costs on society: the costs of building and managing infrastructure to provide more even and reliable flows, and the economic and social costs of floods and droughts that occur in spite of these investments.

Ironically, some regions could be subjected to both increases in droughts and increases in floods if climate becomes more variable. Even without increases in variability, both problems may occur in the same region. In California, where winter precipitation falls largely as snow, higher temperatures will increase the ratio of rain to snow, shifting peak runoff toward the period of time when flood risk is already highest. At the same time, summer and dry-season runoff will decrease because of a decline in snowpack and accelerated spring melting.

4.5. Floods

Flooding is the nation’s most costly and destructive natural disaster. A change in flood risks is therefore one of the potential effects of climate change with the greatest implications for human well-being. Few studies have looked explicitly at the
implications of climate change for flood frequency, in large part because of the difficulty of getting detailed regional precipitation information from climate models and because of the substantial influence of both human settlement patterns and water-management choices on overall flood risk. Floodplain development places more people and property at risk and it reduces a basin’s capacity to naturally absorb flood flows.

Future flood damages will depend on many factors. Among the most important are the rate and style of development in the floodplains, the level and type of flood protection, and the nature of climate-induced changes in hydrological conditions, sea levels, and storm surges. As noted earlier, regional and local changes in hydrological conditions attributable to a greenhouse warming are uncertain but research to date suggests that there is a risk of increased flooding in California. In any case, flooding depends not only on average precipitation but on the timing and intensity of precipitation—two characteristics not well modeled at present.

4.6. Droughts

Water managers must also be concerned about the risks of droughts. Droughts vary in their spatial and temporal dimensions and are highly dependent on local management conditions and the perceptions of local water users. No single definition of drought applies in all circumstances; thus determining changes in drought frequency or intensity that might be expected to result from climate changes is complicated. Most past studies have focused on evaluating changes in low-flow conditions and probabilities.

Quantifying the socioeconomic impacts of a drought is difficult, and comprehensive damage estimates are rarely available. Agriculture, the economic sector most susceptible to water shortages, is likely to suffer reduced crop production, soil losses due to dust storms, and higher water costs during a drought. But non-climatic factors can play an important role in limiting, or worsening, the impacts of climate. Agricultural losses during California’s six-year drought from 1987-1992 were reduced by temporarily fallowing some land, pumping more groundwater, concentrating water supplies on the most productive soils and higher value crops, and purchasing water in spot markets to prevent the loss of tree crops. Direct economic losses to California’s irrigated agriculture in 1991 were estimated at only $250 million, less than 2 percent of the state’s total agricultural revenues (Nash and Gleick 1993; U.S. Army Corps of Engineers 1994).

A prolonged drought affects virtually all sectors of the economy. Urban users in California paid more for water and were subject to both voluntary and mandatory conservation programs. Landscaping and gardening investments and jobs were lost. Electricity costs, as described above, rose more than $3 billion because of reduced hydropower power production. Recreation was adversely impacted. Visits to California state parks declined by 20 percent between 1987 to 1991, and water-based activities such as skiing and reservoir fishing declined (Gleick and Nash 1991). During this drought, the state’s environmental resources may have suffered the most severe impacts. Most major fisheries suffered sharp declines and many trees were weakened or killed by the lack of precipitation, increasing the subsequent risk of forest fires (Nash 1993;
Brumbaugh et al. 1994). Many of these ecosystem impacts are never monetized or quantified.

5.0 Coping and Adaptation: Policy Directions

5.1. Review of Policy Recommendations from Peer-Reviewed Sources

For over a decade, scientists have been producing formal, peer-reviewed recommendations for integrating their work into policy. We synthesize their suggestions for coping and adaptation from several key reports. Each recommendation is followed by one or more references indicating which reports included it. While only the California Energy Commission report (1991) is wholly specific to California, it should be noted that most focus on the Western United States, including California, because in general impacts of climate change on water resources are expected to be greater in areas which are already water-stressed. The following reports are used in this synthesis:

- (Waggoner 1990) – The American Association for the Advancement of Science (AAAS) published this volume detailing the setting, impacts, and responses for U.S. water resources. It was the most in-depth, interdisciplinary, and scientifically sophisticated report until the National Assessment (Gleick and others 2000).

- (California Energy Commission 1991) – The first report by a California State agency was mandated by AB4420 in 1988. The CEC report is specific to California, and produced under the auspices of a California Agency. It should be noted that its recommendations were based on the assumption that snowmelt timing will be the primary hydrologic variable altered by climate change, and precipitation was held constant in its scenarios. In our interviews, California water policymakers cited it repeatedly as an influential early document.

- (American Water Works Association 1997) – The Public Advisory Forum of the American Water Works Association issued a succinct set of recommendations to water managers. As the largest U.S. professional water utilities and providers’ organization, its peer-reviewed document should carry weight with water managers.

- (Gleick and others 2000) – The report of the Water Sector of the National Assessment on the Potential Consequences of Climate Variability and Change for the United States provides a regional and national overview of the impacts of climate change on water resources.

- (Wilkinson and others 2002) – The draft report of the California Regional Assessment Group of the National Assessment provides an overview of impacts for the State’s ecosystems, economy, society, human health, and other areas. It includes a major chapter on water resources. In its section on recommendations for adaptation, it quotes in full the Water Sector (Gleick and others 2000) and the AWWA reports (American Water Works Association
In addition, it offers other recommendations, which are cited in this summary.

These reports were all peer-reviewed, except the CEC report, which is included because of its historical influence and the degree of its specificity to California. A general theme in the recommendations is the adoption of “no-regrets” strategies, which are defined by the IPCC as policies that would have net social benefits whether or not there is anthropogenic climate change (McCarthy et al. 2001).

In the context of broad scientific consensus that global climate change is real and expected with a very high degree of confidence, these recommendations also implicitly or explicitly acknowledge that specific regional effects are not yet predictable with high certainty. This point was emphasized in the recommendations of the AAAS report (Waggoner 1990).

It is also notable that none of the reports contradict each other on any specific recommended measure. This consistency follows from the general scientific consensus on global climate change, but also from the generally conservative nature of the suggestions. Even the California Energy Commission report (1991), with its less sophisticated scientific basis, produced recommendations that are consistent with those of later efforts. Some of the recommendations have been acted on, and some responses are currently being devised.

We divided the list below into four categories: Current No-Regrets Actions, Communication and Collaboration, Research Needs, and Information Gathering.

### 5.2. Current No-Regrets Actions

- Governments and agencies should reevaluate legal, technical, and economic procedures for managing water resources in the light of the climate changes that are highly likely (Waggoner 1990; American Water Works Association 1997; Gleick and others 2000; Wilkinson and others 2002).

- Governments should encourage flexible institutions for water allocation including water markets (Waggoner 1990).

- Planning should occur over appropriate regions, which may or may not correspond to current boundaries (Waggoner 1990). This approach would elevate the importance of hydrologic boundaries over political boundaries.

- Increased funding is necessary for interdisciplinary research necessary to address the broad-based impacts and effects of climate change (Waggoner 1990).

- Flexible decisions should be encouraged, particularly in the design and construction of new projects (Waggoner 1990; Gleick and others 2000; Wilkinson and others 2002).

- Opportunities for water conservation, demand management, and efficiency should be explored and encouraged (Waggoner 1990; California Energy Commission 1991; Gleick and others 2000; Wilkinson and others 2002).
• Private enterprises should decrease vulnerabilities to the hydrologic effects of climate change through water transfers or construction of new infrastructure (Waggoner 1990).

• The State should improve both weather and flood forecasting (California Energy Commission 1991).

• The State should assess Delta levees’ strength with respect to increasing sea level rise (California Energy Commission 1991).

• Water managers should carefully consider increased storage in new surface or underground storage facilities (California Energy Commission 1991; Gleick and others 2000). The California Energy Commission (1991) gave the most specific recommendation, at four million acre feet, plus storage for maintenance of Delta salinity levels. This estimate, however, should be taken in the context of the relative generality of its science.

• Existing dams should have temperature controls added for fish species that require cold water downstream (California Energy Commission 1991).

• New supply should come from both traditional and alternative places, such as wastewater reclamation and reuse, water marketing and transfers, and possibly desalination (Gleick and others 2000).

• Prices and markets should be adjusted to balance supply and demand (Gleick and others 2000).

• Water laws should be updated and improved water laws, including review of the legal allocation of water rights (American Water Works Association 1997; Gleick and others 2000).

• Managers should plan and invest for multiple benefits (e.g. Water supply, energy, wastewater, and environmental benefits result from water use efficiency increases) (Wilkinson and others 2002).

• Site-dependant application of climate change science to stormwater management strategies should be used, including approaches like increasing permeable surfaces in urban areas (Wilkinson and others 2002).

5.3. Communication and Collaboration

• Water organizations should communicate regularly with scientists, with the dual goals of communicating scientific advances to managers and communicating what knowledge is necessary from scientists for effective management (Waggoner 1990; American Water Works Association 1997; Gleick and others 2000).

• “Those reporting about climate change bear a special responsibility for accuracy, conveying the real complexities and uncertainties, and not oversimplifying. Scientists must make extra effort to explain clearly in conservative and understandable terms.” (Waggoner 1990).
• Timely flows of information between scientific community, public, and water management should be facilitated (American Water Works Association 1997; Gleick and others 2000).\(^1\)

5.4. Research Needs
There is no shortage of research needs, several of which are listed below. The PIER project has developed a research agenda of short-term (1 to 3 years), mid-term (3 to 10 years), and long-term (10 to 20 years) goals, to attempt to answer some of the most important questions facing California policymakers and scientists. Funding is not available for all of the necessary work. Roos (2003) describes this “roadmap” at www.energy.ca.gov/reports/2003-04-16_500-03-025FA-II.PDF. This roadmap has been approved by the California Department of Water Resources to help it develop future research efforts.

Other research needs include:

• Climate change scientists should focus on the timeframes and spatial scales relevant to water managers, who are concerned with watershed-level predication and decadal time scales (Waggoner 1990).

• Improve GCMs to more accurately represent hydrologic impacts, water resource availability, overall hydrologic impacts, and regional impacts (Waggoner 1990; Gleick and others 2000).

• Improve downscaling of GCMs\(^2\) (Gleick and others 2000).

• Planners should reassess water transfer plans for the Sacramento-San Joaquin Delta, particularly in light of predicted sea-level rise (California Energy Commission 1991).

• Changing land use patterns should be examined as a coping mechanism (Gleick and others 2000).

• Scientists and engineers should reexamine engineering designs, operating rules, contingency plans, and water allocation policies under a wider range of climate scenarios\(^3\) (American Water Works Association 1997; Gleick and others 2000).

• Economists should investigate economic effects of climate change and of adaptations to climate change (Gleick and others 2000).

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\(^1\) Several recent conferences illustrate that this information flow is currently happening. For example, at a recent CALFED meeting detailing modeling projects, several local stakeholder groups were represented, along with larger environmental groups and many branches of government.

\(^2\) This is one area that continues to see significant advances (e.g., Knowles and Cayan 2002; Snyder et al. 2002). Interestingly, Knowles and Cayan (2002) acknowledge water managers at DWR for providing motivation for their work.

\(^3\) See (Yao and Georgakakos 2001).
• Hydrologists should research effects on groundwater quality, recharge and flow dynamics has been lacking (Gleick and others 2000).

• All sectors should look into mitigation through decrease in fossil fuel use (California Energy Commission 1991; American Water Works Association 1997).

5.5. Information Gathering
• The state should improve hydrologic monitoring, including improving data on storm frequency (California Energy Commission 1991; Gleick and others 2000).

• Water quality monitoring should be increased (California Energy Commission 1991).

• The State should reevaluate risks to flood zones at intervals of 20–30 years (California Energy Commission 1991).

• Information on the relative costs and benefits of non-structural management options, like demand management or decreased floodplain development should be produced (Gleick and others 2000).

• Agencies should explore the vulnerability of both structural and nonstructural water systems (American Water Works Association 1997).

• Economic and market tools should be explored, but Wilkinson and others (2002) caution that this should not be equated with privatization.

In the context of these recommendations for types of action, the following more specific items are available within several major topical categories. Among the new tools water agencies and managers are exploring are (1) incentives for conserving and protecting supplies, (2) opportunities for transferring water among competing uses in response to changing supply and demand conditions, (3) economic changes in how water is managed within and among basins, (4) evaluating how “re-operating” existing infrastructure can help address possible changes, and (5) new technology to reduce the intensity of water use to meet specific goals (Gleick and others 2000).

6.0 Coping and Adaptation: Specific Policy Actions
The lessons from existing efforts need to be evaluated in order to understand how they might mitigate (or worsen) the impacts of climate changes. During the twentieth century, dams, reservoirs, and other water infrastructure were designed with a focus on extreme events such as the critical drought periods or the probable maximum flood. This approach provided a cushion to deal with uncertainties such as climate variability (Matalas and Fiering 1977). In recent years, however, the high costs and environmental concerns that now make it difficult to get a new project approved also make it likely that the projects that are undertaken will have less redundancy built into their water supply and control facilities than the projects built earlier (Frederick 1991).

Managing water resources with climate change could prove different than managing for historical climate variability because: (1) climate changes could produce hydrologic conditions and extremes of a different nature than current systems were designed to
manage; (2) it may produce similar kinds of variability but outside of the range for which current infrastructure was designed; (3) it assumes that sufficient time and information will be available before the onset of large or irreversible climate impacts to permit managers to respond appropriately; (4) it assumes that no special efforts or plans are required to protect against surprises or uncertainties (Gleick and others 2000).

The California Department of Water Resources’ California Water Plan (Bulletin 160) is the most important statewide water-planning document for California. Past editions have given short shrift to climate change. However, a draft chapter of Bulletin 160-2003 on the topic of “Planning for an Uncertain Future” contains a major segment focusing on climate change. This inclusion represents an important acknowledgement by a major state agency of the realities and necessities inherent to a changing climate.

6.1. Water Planning and Management

Decisions about long-term water planning depend on climatic conditions and what humans do to respond and adapt to those conditions. In the past, these decisions relied on the assumption that future climatic conditions would have the same characteristics and variability as past conditions. Dams are sized and built using available information on existing flows in rivers and the size and frequency of expected floods and droughts. Reservoirs are operated for multiple purposes using the past hydrologic record to guide decisions. Irrigation systems are designed using historical information on temperature, water availability, and soil water requirements.

This reliance on the past record now may lead us to make incorrect—and potentially dangerous or expensive—decisions. Given that risk, one of the most important coping strategies must be to try to understand what the consequences of climate change will be for water resources and to begin planning for those changes. Emphasis on planning and demand management rather than construction of new facilities marks an important change in traditional water-management approaches, which in the past have relied on the construction of large and expensive infrastructure.

O’Connor et al. (1999) examined the sensitivity and vulnerability of community water systems to climate change by surveying 506 managers. Water-system managers do not dismiss the issue of climate change, but they have been reluctant to consider it in their planning horizons until they perceive a greater degree of scientific certainty about regional impacts. Interestingly, most managers admit that they expect disruptions in daily operations caused by changes in climate variability. Experienced and full-time water managers were more likely to consider future climate scenarios in planning than inexperienced or part-time managers. O’Conner et al. (1999) offered some conclusions and discussion of policy implications of their survey:

- Moving away from exclusive reliance on surface water by integrating surface and groundwater management reduced vulnerability to climate fluctuations.
- Continued efforts to improve research and to communicate the risk of climate changes to water managers, especially at the local level, will be useful.
Local governments should consider creating more full-time water manager positions to attract top professionals capable of considering long-term issues and concerns in planning.

6.2. Sea Level Concerns

Five hundred and twenty miles of levees that protect the Delta Islands are non-project (outside the federal flood control project) levees that are currently built to HMP (Hazard Mitigation Plan) standards. Local districts responsible for maintaining these levees are challenged by poor foundations and regulations to protect levee wildlife habitat. An estimated expenditure of from $613 million to $1.28 billion would bring the levees up to Public Law 84-99 standard (16 ft wide and 1.5 ft. free board above a 100-year flood) (personal communication, Department of Water Resources, 2003).

To increase these non-project levees by one additional foot (to accommodate sea level rise) would increase the cost by about $300 million. There are currently 220 miles of project levees in the Delta region, which are mostly up to PL 84-99 standards. It will cost over $130 million to accommodate an increase of a foot in this levee system. An additional increase in the water level due to sea level rise would necessitate not only an increase in the levee height, but also strengthening of the levees.

6.3. Modifying Operation of Existing Systems

There are two critical issues associated with using existing facilities to address future climate change: can they handle the kinds of changes that will occur; and at what economic and ecological cost? There have been few detailed analysis of either of these questions, in part because of the large remaining uncertainties about how the climate may actually change. Also, the principle of local public participation is increasingly being implemented. Involving the public in water management decisions has taken steps forward in California through the CALFED process (Jacobs et al. 2003) and through the public advisory committee role in the production of this document.

Regardless, without precise information on the characteristics of future climate, the best that water managers can hope to do may be to explore the sensitivity of their system to a wider range of conditions than currently experienced and to develop methods or technologies that can improve operational water management.

The work of Lettenmaier et al. (1999) and Yao and Georgakakos (2001) reinforce the conclusion that effective operation of complex systems can reduce impacts of climate change, but only if implemented in a timely and dynamic manner. Lettenmaier et al. (1999) addressed this question of response to climate change for a series of water systems around the United States. They noted that reservoir systems buffer modest hydrologic changes through operational adaptations. As a result, the effects of climate change on the systems they studied tend to be smaller than the underlying changes in hydrologic variables. They concluded that significant changes in design or scale of water management systems might not be warranted to accommodate climate changes alone, although this obviously depends on the ultimate size of the changes. They urged a concerted effort to adjust current operating rules or demand patterns to better balance
the existing allocated purposes of reservoirs, which requires planning and participation by water managers.

Other steps should include determining quantitative impacts from climate change on water supply and flood control including a systematic review and evaluation of all major multi-purpose reservoirs for water supply and flood control and their ability to adapt under current operating rules. Also, evaluation of alternative options for water management including evaluation of measures to improve water supply and quality, reduce demands throughout the State, maintain and restore ecosystems, reoperate reservoirs, and adapt to sea level rise in the Delta. The work will emphasize increased flexibility in both physical systems and institutional mechanisms in order to permit a greater range of response. Supply and quality measures will be particularly important in regions dependent on imported supplies.

Forecasting peak flows under different climate scenarios remains highly uncertain because of difficulties in projecting the details of regional precipitation patterns. Nevertheless, it may be prudent to re-evaluate design and management practices of existing infrastructure, with the goal of updating the information used for these purposes. In particular, more frequent updating of statistics on rainfall and runoff timing, frequency, and magnitude would be valuable.

6.4. New Supply Options

Traditional water-supply options, such as dams, reservoirs, and aqueducts may still have an important role to play in meeting water needs in parts of the United States. Because new infrastructure often has a long lifetime, it is vital that the issue of climate change be factored into decisions about design and operation.

While new supply options can be expensive and controversial traditional, water-supply options such as dams, reservoirs and aqueducts may still have an important role to play in meeting water needs of California. At present the Department of Water Resources in collaboration with United States Bureau of Reclamation (USBR), Contra Costa Water district (CCWD), and local agencies are looking into enlarging instream storages in Shasta and Millerton reservoirs, off-stream storage options such as Red Bank Project, Colusa Reservoirs and Sites reservoirs, enlarging Los Vaqueros reservoir, and flooding four Delta islands, namely: Bacon, Web, Bouldin, and Holland. These projects will increase supply reliability, improve water quality, and improve some environmental issues such as providing wildlife habitats and cooler water for salmon migration.

Aside from new water-supply infrastructure, options to be considered include wastewater reclamation and reuse, water marketing and transfers, and even limited desalination where less costly alternatives are not available and where water prices are high. None of these alternatives, however, are likely to alter the trend toward higher water costs. They are either expensive relative to traditional water costs or their potential contributions to supplies are too limited to make a significant impact on long-term supplies. Ultimately, the relative costs, environmental impacts, and social and
institutional factors will determine the appropriate response to greenhouse-gas-induced climate changes.

Major (1998) notes that incremental construction can allow for adaptation but adds that planners must choose robust designs to permit satisfactory operation under a wider range of conditions than traditionally considered. Designing for extreme conditions, rather than simply maximizing the expected value of net benefits, should be considered. He also suggests postponement of irreversible or costly decisions.

6.5. Demand Management, Conservation, and Efficiency

Demand management, especially in the face of population increase, is critical to mitigate loss of water supply. More water-efficient methods in agricultural, industrial, and urban water have been effective in the past in this capacity (Owens-Viani et al. 1999) and should be further developed and implemented.

As the economic and environmental costs of new water-supply options have risen, so has interest in exploring ways of improving the efficiency of both allocation and use of water resources. Improvements in the efficiency of end uses and sophisticated management of water demands are increasingly being considered as major tools for meeting future water needs, particularly in water-scarce regions where extensive infrastructure already exists (Vickers 1991; Postel 1997; Gleick 1998; Dziejulewski 1999; Vickers 1999). Evidence is accumulating that such improvements can be made more quickly and more economically, with fewer environmental and ecological impacts, than further investments in new supplies (Owens-Viani et al. 1999).

The largest single user of water is the agricultural sector and in some places a substantial fraction of this water is lost as it moves through leaky pipes and unlined aqueducts, as it is distributed to farmers, and as it is applied to grow crops. In water-short areas, new techniques and new technologies are already changing the face of irrigation. Identifying technical and institutional ways of improving the efficiency of these systems in a cost-effective manner will go a long way toward increasing agricultural production without having to develop new supplies of water (Gleick 1998).

In an assessment of urban water use, Boland (1997, 1998) shows that water conservation measures such as education, industrial and commercial reuse, modern plumbing standards, and pricing policies can be extremely effective at mitigating the effects of climate change on regional water supplies. A number of water-system studies have begun to look at the effectiveness of reducing system demands for reducing the overall stresses on water supplies, both with and without climate changes. Wood et al. (1997) and Lettenmaier et al. (1999) noted that long-term demand growth estimates had a greater impact on system performance than climate changes in circumstances when long-term withdrawals are projected to grow substantially. Actions to reduce demands or to moderate the rate of increase in demand growth can therefore play a major role in reducing the impacts of climate changes. Far more work is needed to evaluate the relative costs and benefits of demand management and water-use efficiency options in the context of a changing climate.
6.6. Economics, Pricing, and Markets

Prices and markets are also increasingly important tools for balancing supply and demand for water and hence for coping with climate-induced changes. Economists and others are beginning to advocate an end to the treatment of water as a free good. This can be accomplished in many different ways. Because new construction and new concrete projects are increasingly expensive, environmentally damaging, and socially controversial, new tools such as the reduction or elimination of subsidies, sophisticated pricing mechanisms, and smart markets provide incentives to use less water, produce more with existing resources, and reallocate water among different users. Water marketing is viewed by many as offering great potential to increase the efficiency of both water use and allocation (NRC 1992; Western Water Policy Review Advisory Commission 1998). As conditions change, markets can help resources move from lower-to higher-value uses.

Water transfers in itself do not create new water, but simply reallocate water within a region or between regions. This process enables a better distribution of water throughout the State from areas of surplus to areas in need. In a guide to water transfer, the California State Water Resources Control Board stipulates that a person who transfers water should hold the rights to it and should not injure another water right holder or unreasonably affect instream beneficial uses. For efficient water marketing and smooth transferring of water the users should have a clear idea about the transfer costs.

Water banks acts as storage locations where excess water is held until a withdrawal is necessary. The storage location could be either a surface reservoir or a groundwater aquifer. Water banks enhance the versatility of water transfers and marketing, though many questions about equity, pricing, and operations remain to be answered.

The characteristics of water resources and the institutions established to control them have inhibited large-scale water marketing to date. Water remains underpriced and market transfers are constrained by institutional and legal issues. Efficient markets require that buyers and sellers bear the full costs and benefits of transfers. However, when water is transferred, third parties are likely to be affected. Where such externalities are ignored, the market transfers not only water, but also transfers the benefits that the water provides to a non-consenting third party to the parties involved in the transfer. A challenge for developing more effective water markets is to develop institutions that can expeditiously and efficiently take third-party impacts into account (Loh and Gomez 1996; Gomez and Steding 1998; Dellapenna 1999). As a result, despite their potential advantages, prices and markets have been slow to develop as tools for adapting to changing supply and demand conditions.

California’s emergency Drought Water Banks in the early 1990s helped mitigate the impacts of a prolonged drought by facilitating water transfers among willing buyers and sellers. Dellapenna (1999) and others have noted, however, that the California Water Bank was not a true market, but rather a state-managed reallocation effort that moved water from small users to large users at a price set by the state, not a functioning market. More recent efforts to develop functioning markets on smaller scale have had some
success (California Department of Water Resources, rubicon.water.ca.gov/b16098/v2txt/ch6e.html).

Temporary transfers may be particularly useful for adapting to short-term changes such as climate variability. They are less effective in dealing with long-term imbalances that might result from changing demographic and economic factors, social preferences, or climate. At some point, the historical allocation of water becomes sufficiently out of balance to warrant a permanent transfer of water rights.

6.7. State Water Law

Few analyses have tried to evaluate how climate change impacts may affect, and be affected by, water laws and regulatory structures. Water in its many different forms has been managed in different ways at different times, and in different places around the country, leading to complex and sometimes conflicting water laws. At the federal level, laws such as the Clean Water Act and the Safe Drinking Water Act have played a major role in how water is used, allocated, and treated. Yet these national tools, not to mention the many regional and local laws affecting water, were all designed without considering the possibilities of climate changes (Trelease 1977). Even without such changes, efforts are needed to update and improve legal tools for managing and allocating water resources. Tarlock (1991) evaluated how western water laws may begin to conflict as climate change affects water availability and reliability. Dellapenna (1999) argues that the current fragmented approach is obsolete and that integrated water management at the basin level is required, both with and without climate changes. He further argues, however, that climate changes are likely to exacerbate the problems that already exist under inefficient management.

6.8. Hydrologic and Environmental Monitoring

Better data on hydrology and land use are critical to California’s successful adaptation to expected climate change. Changes in hydrology are among the most certain of climate change impacts and good hydro-meteorological data are the starting point for evaluating the capabilities of the current water supply and flood protection systems to continue to serve the people of California. Hydrological data are used in the design and operation of water supply systems and flood control works, the provision of environmental needs, and in design of other infrastructure. Several State agencies have ongoing climate, water, and land use/land cover monitoring programs. But there are important gaps, particularly in areas where greater changes are anticipated. At a minimum, data must be collected in several important categories, including:

- Enhance measurements of precipitation and related climate data, streamflow, snowpack, and ocean and Delta water levels.
- A water quality sampling network designed to look at changes expected from climate change.
- More systematic sea-level measurements in the San Francisco Bay and Delta region, and elsewhere along California’s coast.
- Enhanced land use and cover monitoring within the State.
Finally, it is important to continue to collect, maintain, and evaluate records from existing California stations, incorporating data from recent years. Efforts should be made to prevent cuts in monitoring and data collection due to budget constraints.
7.0 Citations


Gleick, P. H. 1987b. ”Regional Hydrologic Consequences of Increases in Atmospheric Carbon Dioxide and Other Trace Gases.” Climatic Change 10(2): 137–161.


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Accounting for Climate Change

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Accounting for Climate Change

By Maurice Roos, DWR

In recent years, evidence that global climate will have significant effects on water resources in California has continued to accumulate. Climate change can affect the amount, timing, and form of precipitation, whether rain or snow, that California receives, as well as the sea level of the Pacific Ocean. Moreover, changes in weather, especially temperature, and atmospheric composition can affect water use and consumption. Changes in climate have occurred during the 20th century, with noticeable warming in the last two decades.

Most scientists feel that changes during the last several decades are likely mostly due to human activities, but natural causes and variability cannot be ruled out as a significant component. Likewise, projections of amount of warming and other climate changes during the 21st century are wide ranging, depending on assumptions and models.

A major cause of expected climate change is the increasing amounts of greenhouse gases, such as carbon dioxide, in the atmosphere as a result of man’s activities. These gases, as well as water vapor, allow solar radiation to pass inward through the atmosphere, but trap the longer wave infrared radiation reflected back from the earth’s surface. Greenhouse gases are accumulating in the atmosphere; the following chart shows the gradual build up in carbon dioxide at Mauna Loa in Hawaii, as measured by Scripps Institution of Oceanography scientists. The annual cycle is caused by northern hemisphere vegetation uptake during the growing season. Other significant greenhouse gases are methane, nitrous oxide, halocarbons (like freon and its replacements), and, of course, water vapor itself. Cloud cover is an important element in the global radiation balance.

Whatever the causes, the prospects of significant changes warrant examination of how the State’s water infrastructure and natural systems can accommodate or adapt to climate changes and whether more needs to be done to detect, evaluate and respond to water resource system effects. Many uncertainties remain, primarily on the degree of change to be expected. Responsible planning requires that the California water planning community work with climate scientists and others to reduce these uncertainties and to begin to prepare for those impacts that are well understood, already appearing as trends, or likely to appear. In this section we review possible impacts and address some of the responses appropriate for water planners and managers.
By and large, reservoirs and water delivery systems and operating rules have been developed from historical hydrology on the assumption that the past is a good guide to the future. With global warming, that assumption may not be valid.

Significant changes in climate are projected for the latter part of this century due to global warming. These potential changes are expected to affect many of our water resources systems. Some of the more important changes would arise from temperature increases, which would raise temperate zone snow elevations and change the pattern of runoff from mountain watersheds, thereby affecting reservoir operation. Other consequences include sea level rise, which could adversely affect the Sacramento San Joaquin River Delta, a major source of water supply for the State; possibly more extreme precipitation and flood events; changes in water consumption by crops and wildlands; and water temperature problems for anadromous fish.

The California Water Plan first briefly addressed climate change a decade ago in a sidebar in Bulletin 160-93 when there was less consensus that global warming was beginning. Prior to that, the California Energy Commission had produced an extensive report in 1991, in response to 1988 legislation, which had significant discussion on reduced snowpack and changing runoff patterns, sea level rise, and water temperatures. This was the first major report by a State agency on the subject.

**Climate Projections**

The most well known climate change projections by year 2100, the end of the century, due to the increase in greenhouse gases have been developed by the Intergovernmental Panel on Climate Change. The IPCC was jointly established in 1988 by the World Meteorological Organization and the United Nations Environment Programme to study climate change. The IPCC has issued several reports since 1990 outlining possible global warming and other potential effects of climate change as a result of increased greenhouse gases originating from human activities.
A good assessment of the state of research on the potential consequences of climate change on water resources in the United States, including what is known and what is not known, is the report of the National Water Assessment Group for the U.S. Global Change Research Program (Gleick and Adams, 2000).

The most recent IPCC Working Group I Summary Report, in its third assessment (IPCC, 2001), projects a 1990 to 2100 average surface temperature increase of around 3 degrees C, with a range of 1.4 to 5.8 degrees (2.5 to 10.4 degrees F). The increase in global temperature during the 20th century was estimated to be about 0.6 degrees C (1.0 degree F), much of which occurred by 1940, and a recent significant increase after 1980 which is believed to be primarily of human origin. Because of warmer temperatures, some increase in global evaporation and therefore more precipitation is projected for the 21st century, more likely at higher latitudes north of California.

The chart shows temperature trends for three groups of stations in California during the 20th century. What is notable is the urban heat island influence, wherein the counties with large populations show more warming than rural counties. Although not directly related to greenhouse gas increases, the local urban warming does matter to local residents because it affects their lives and local environment.

Sea level (IPCC, 2001) is projected to rise around 0.5 meter (1.6 feet) by 2100, with a range of 0.1 to 0.9 meters (0.3 to 2.9 feet). The rate during the 20th century appears to have been around 0.2 meters (0.7 feet) with a range of 0.1 to 0.25 meters (0.3 to 0.8 feet). The 0.2-meter figure is consistent with the historical trend at the Golden Gate tide station, although it is possible that tectonic movement, or settlement, has influenced the stages there.
Figure 2
Long term average temperatures at different locations in California (J. D. Goodridge)

Figure 3:
Golden Gate Annual Average and 19-Year Mean Tide Levels

Note: This figure was updated 12/08/04
There is a general expectation that a warmer climate would lead to more intense precipitation events, potentially causing somewhat bigger floods and more intense convective storms, thereby affecting the rainfall statistics used for storm drainage design. The IPCC report rates prediction confidence in more intense precipitation events as “very likely, over many areas”. A couple of recent research studies attempting to downscale global climate model results to the watershed scale in California indicated substantial increases in the size of floods.

The increase in carbon dioxide, from the current 370 ppm to perhaps 600 or 700 ppm is expected to benefit growth of many food crops, provided the water supply is adequate and temperatures don’t get too hot. Higher carbon dioxide concentrations in the air could partly offset the higher water use (evapotranspiration) in agricultural production resulting from warmer temperatures.

Warmer air and less snowpack would be expected to raise average stream and estuary water temperatures. This would increase the problem for cold-water fisheries, including salmon and steelhead.

All of these projected changes, as well as some not yet identified, are likely to affect the hydrologic cycle and the water resources of California.

**Major Consequences to Water Resources Systems**

There are a large number of potential effects on California water resources infrastructure due to global warming. Much depends on the degree of warming and whether future changes are small or large. There are potential impacts on snowpack accumulation and melting, runoff patterns, water supply, sea level, floods and droughts, water demands, water temperature, plant and animal life including livestock, hydroelectric power, wild fires, recreation, water quality, soil moisture, groundwater, and ecosystems. Only five of these will be dealt with in the section: water supply, sea level rise, extremes (primarily floods), water requirements, and river water temperature.

**Water Supply**

The most important parameter in determining runoff and therefore water supply is precipitation. Regional precipitation predictions in the huge general circulation models of the atmosphere have not been reliable, and vary greatly among the different models. As a general rule, a warmer world would mean more evaporation, hence more precipitation overall. But where and when the precipitations falls is all-important. Some researchers think that climate warming might push the winter storm track on the West Coast further north, which would mean a drier California. On the other hand, some of the new GCM’s, including the two used in the National Water Assessment, increase average California precipitation.

If warming occurs, one impact is considered relatively certain. On average, snow levels in the mountains will rise and the average amount of snow covered area and the snowpack will decrease. A reasonable estimate is about 500 feet of elevation change for every degree C rise. Many early studies, including the 1989 National Academy of Science report, have used 3°C as a benchmark of scenarios, which is still in the midrange of the new IPCC predictions, as a reasonable 100-year projection for the western states. This would mean a rise of about 1,500 feet in average snow levels. Historical average snow elevations on April 1 (the usual peak of the snow accumulation season) range from about 4,500 feet in the north above Shasta Lake to around 6,000 feet in the southern Sierra. Earlier DWR assessments some years ago came up with estimates for a rise of 1,500 feet in the average freezing level during storms and assuming the amount of
precipitation remained approximately the same. In the Sacramento River region, only about one fourth of the snow zone would remain with an estimated decrease of nearly 3 million acre-feet of April through July runoff. The impact would be much less in the higher elevation southern Sierra. About seven tenths of the San Joaquin/Tulare Lake region snow zone would stay.

Not all the spring runoff comes from melting snow. In the northern Sierra, spring rainfall is an important contributor. The estimated average reduction in Sacramento River region April through July runoff was projected to be 43 percent, leaving 57 percent of current runoff. The southern Sierra impact was less with 23 percent reduction overall. The total runoff reduction for all watersheds was 33 percent. These results were crude and preliminary, but have been roughly confirmed by more recent work by Scripps and others. A Knowles and Cayan study (Scripps, 2001) included a 2090 projection from the Parallel Climate Model with 2.1 degrees C (3.8 F) of warming to come up with a 50 percent reduction in April snow water content and a 4.5 million acre-feet reduction in April through July runoff.

**Figure 4**
Projected Snow Pack as a percentage of Average 1995-2005 (Knowles and Cayan)

Some GCM studies project significantly more winter season precipitation in California, some models are drier. It is possible for the southern Sierra snowmelt runoff to increase in the wetter scenarios, albeit from less area. All models so far show less snowmelt runoff in the northern Sierra.

Less spring snowmelt could make it more difficult to refill winter reservoir flood control space during late spring and early summer of many years, thus potentially reducing the amount of surface water available.
during the dry season. Lower early summer reservoir levels also would adversely affect lake recreation and hydroelectric power production, with possible late season temperature problems for downstream fisheries.

April-July runoff, primarily snowmelt, in California major rivers (including the Trinity River which supplies water to the Central Valley Project) amounts to about 14 million acre-feet on average. This is about 40 percent of the estimated total State net demand for agricultural and urban water use. Replacing that would take about 4 to 5 MAF of reservoir storage, increased conveyance facilities and other measures. Of course, if precipitation increases, reductions in runoff would be less, especially in the higher elevation southern Sierra.

Not all river systems would be equally affected; much depends on the existing storage capacity. One would expect only a slight impact on the Stanislaus River, for example, where the ratio of storage to average annual runoff is about 2.5 and winter spills on flood control releases are uncommon. The American River ratio is about 0.64 so it is likely to be more affected.

One can look at our recent hydrologic history to see if any trends are evident. The chart shows the record for the Sacramento River system for the 20th century. April through July runoff is plotted as a percentage of total water year runoff. There really was not much trend until the last half of the century, when the percentage of April through July runoff begins to show a progressive decline. Changes in North Pacific ocean current patterns, known as the Pacific Decadal Oscillation may explain part of the trend. The same effect is noted on the southern Sierra rivers, but the decrease is less. The same downward pattern in Sacramento River snowmelt runoff can be seen on a chart plotting volume with years, but the fit is poorer and a consistent trend not as evident.
Sea Level Rise

A second potential impact is sea level rise. This would lead eventually to problems in certain coastal areas with low-lying salt marshes and other lands protected by dikes. But the big impact on California water supply could be in the Sacramento-San Joaquin Delta. There the problem would be two-fold: (1) problems with the levees protecting the low-lying land, much already below sea level and (2) increased salinity intrusion from the ocean which could degrade fresh water transfer supplies pumped at the southern edge of the Delta or require more fresh water releases to repel ocean salinity.

Many of the central Delta levees are built on unstable peat soil and are vulnerable to high water peaks. The potential impact of sea level rise on these levees depends on the rate of increase. A small rise can probably be tolerated by the levee system; a major rise of one foot or more could cause significant problems. Extrapolating current trends yields about 0.4 foot by year 2050. The IPCC median projection is about 1.6 feet by 2100. One perspective is that a one-foot rise would transform the current 100-year high tide peak at Antioch, a western Delta station, into about a 10-year event. Thus the rare high event could become a more frequent threat to the Delta levees and the role they play in protecting the sensitive Delta.
Accounting for Climate Change

Since California is tectonically active, it is the net combined effect of geologic change, rising or falling land, and sea level rise, which matters. The effect of a rising ocean would be magnified where land subsidence is occurring and decreased where uplift is happening.

Salinity intrusion is a function of channel depth and time, increasing rapidly with depth. Climate change induced sea level rise could increase overall channel depths, potentially increasing salinity intrusion and diminishing water quality for south of Delta users. Reduced excess snowmelt in the spring would also mean a longer dry season, that is, more time, for saltwater intrusion. However, depths in the upper estuary and the western Delta may not change that much if the sea level rise is small.

More Extreme Events

A third possible effect could be more extreme events: (1) larger floods and more intense precipitation events, particularly if the wetter winter scenario of the National Water Assessment materializes, and (2) longer drier droughts if other model scenarios are considered.

There is a general relationship between rainfall intensity and the warmness of the climate. Other factors being equal, warm air holds more water vapor than cool air. For a given amount of lift of saturated air, more condensation will occur from warmer as compared to cooler air. Therefore, lifting of the air either orographically by winds blowing over a mountain range, by convective activity (thunderstorms), or by a weather system front has the potential for greater precipitation intensity. Also, higher snow levels in the Sierra Nevada and other high mountains mean more watershed area contributing direct rain runoff during winter storms and less snow accumulation.
Major floods on California’s rivers are produced by slow moving Pacific storm systems, which sweep moist subtropical air from a southwesterly direction into the State. When these moisture-laden weather systems run into the mountains, copious amounts of rain and runoff are produced as the air is lifted by the mountain ranges. Whether the southwesterly winter storm winds would be stronger or weaker if global warming occurs has not been determined. In one simple experiment by the Department of Water Resources on the American River basin east of Sacramento, temperatures of a major storm (like that of February 1986) were raised three degrees Celsius, keeping the strength of the southwesterly winds and the relative humidity the same. The storm runoff increased about 10 percent. If storm intensities increase, it is likely the probable maximum flood used for dam spillway design would be bigger.

Research work by Dr. Michael Dettinger of Scripps Institution of Oceanography and Dr. Norman Miller and associates at Berkeley National Laboratory show an increased risk of large storms and flood events for several GCM scenarios. Since existing flood control facilities in the Central Valley and elsewhere seem to be barely able to accommodate large flood events, like the 1-in-100-year flood, even a modest increase could pose problems. An increase in winter flood control space would conflict with operations for water supply, power and recreation on many of the big multipurpose reservoirs in California. The total volume of maximum winter flood control space requirements on major Central Valley foothill reservoirs exceeds 5.5 million acre-feet.

Increasing winter flood control space generally would make it more difficult to fill reservoirs in the spring. The filling problem would be compounded if spring runoff were reduced because of smaller snowpacks.

Related to flood risk are the rainfall depth-duration-frequency data widely used for designing local storm water control and drainage facilities. It has been suggested that these statistics be updated frequently, at least every 20 years or so. In this way, climate changes will be gradually incorporated into the record and in the rainfall statistics.
Water Use

There are likely to be changes in water use as well as in water supply. Water consumption changes may be small, but because so much land area is involved, amounts could be very significant. Generally, a slightly warmer climate with less frost and a higher atmospheric concentration of carbon dioxide is regarded as beneficial to most food crops.

As a rule, plant evapotranspiration (ET) increases with temperature. Higher carbon dioxide levels, however, reduce water consumption (at least in laboratory tests), and seem to increase yield. In the opinion of knowledgeable researchers, the higher water consumption with warmer temperatures will probably only be partially offset by the carbon dioxide-based reductions. Thus, the net result could be slightly higher agricultural water requirements. Assessing the potential impacts to agriculture is complicated for some annual crops because it may be possible to change the planting season a few weeks, which may result in no net change in water use for that crop.

The whole subject of potential crop ET and water requirements is an important area of investigation for university and agriculture extension service people. In view of further cuts in water availability to California agriculture, changes in ET would be of great importance.

Warmer Water Temperature

Of considerable concern, if California temperatures rise significantly, would be managing salmon and steelhead fisheries. Warmer air temperatures will make it more difficult to maintain rivers cold enough for cold-water fish, including anadromous fish. With reduced snowmelt, existing cold-water pools behind major foothill dams are likely to shrink. As a result, river water temperature could warm beyond a point that is tolerable for the salmon and steelhead that currently stay in these rivers during the summer. Under this scenario, it is doubtful that the existing, cold-water temperature standards in the upper Sacramento River would be able to be maintained. Problems are likely for juvenile steelhead, as well.

A few of the major reservoirs have multilevel outlet structures able to control discharge water temperatures. For many of the others where downstream fisheries require cold water, temperature control structures should be considered and, where feasible, installed.

Colorado River Impacts

The Colorado River in recent years has furnished slightly over half of the total water supply for the South Coast and Colorado River regions of Southern California. With the planned reduction in California diversions to 4.4 million acre-feet it will still furnish about 45 percent of estimated current water demands, a very important portion of the State’s water budget. Because total reservoir storage on the Colorado River exceeds 4 times the average annual runoff of about 15 million acre-feet, its water supplies are not very vulnerable to seasonal shifts in runoff due to less snowpack. Rather it is the total annual amount of runoff which matters. Most of the runoff is generated from a relatively small portion of the basin, on the order of 10 percent, which is the high elevation mountain region. Studies by Nash and Gleick (1993) indicate that percentage changes due to global warming may be somewhat less in the higher watersheds than when modeling the basin as a whole above Glen Canyon dam. Their 1993 report also indicates that about a 10 percent increase in precipitation would be required to offset the drying effect of about the same percentage due to a temperature rise of 2 degrees C.
Some GCM models show more precipitation in the Colorado River basin. Only a modest increase in runoff, on the order of 10 percent, can change the emphasis from water supply shortages to flood control. The message is that what happens on the Colorado River is very important to California, but more studies are needed to assess probable directions of impacts. A slightly drier scenario could rule out interim surplus over the 4.4 million acre-feet for California. Beyond that, under current law, further decreases in runoff would have to be absorbed by Arizona.

Adapting to Change

Even though there are large variances in GCM model results on certain parameters, such as likely future precipitation, some effects are consistent:
- Temperatures will rise, which will affect the extent and amount of winter snowpack in the mountains.
- However, the range in projections of the amount of temperature increase to expect is still quite large.
- Sea levels will rise with a likely minimum rate of 0.2 meter (0.7 feet) in the next century (the apparent recent historical rate) and possibly more.
- Some increase in the intensity of extreme precipitation and flood events is likely.
- Because of generally higher temperatures, some increase in crop and urban greenery water requirements is likely, but not large increases.
- River and estuary water temperatures will rise with increasing problems for cold water fisheries.

What We Need to Know

There are a number of needs for better information regarding climate change on which to base water resources planning. Foremost is better hydrologic monitoring so we can assess trends and changes which are underway. Because weather and hydrology are so inherently variable, many years of consistent and accurate measurements are vital. Besides indicating quantitative changes, the proposed monitoring is necessary feedback into calibrating climate models used for future predictions. Currently there are few good climate data stations in the mountain zones where the more significant changes are expected.

For water systems in California and elsewhere, climate model precipitation is probably the most important parameter. This must be developed at the watershed level for a representative set of future scenarios. The major tool for evaluating the impact on major water project systems would be the CALSIM reservoir system operation (simulation) model developed jointly by DWR and USBR. Development of modified monthly input to CALSIM from the climate models will require help from the research community. The heart of an adaptation program to improve the State’s capacity to operate its complex water management system in the face of different and perhaps a more variable climate depends on assessing simulated operation over long hydrologic time periods. This would enable proactive planning and development of options and strategies to improve water supply and quality, including adapting to sea level rise in the Delta and possibly reoperation for flood control. Initial tests of the CVP-SWP system would more practically be based on a 50-year projection of trends during the past 50 years.

The December 2002 report of the California Floodplain Task Force did take note of the potential for bigger floods and changes in flood frequency with climate change. Conceivably, if more definite
estimates of these changes can be determined from further research with GCM results, some allowance for climate change can be built into the Task Force’s concept of the “reasonably foreseeable flood.”

Evaluation of major multipurpose reservoir flood control aspects is another major need, which would require generation of at least daily inflow from the watersheds. Linking climate and hydrologic models can provide such inflow, but is a major task. Some screening by climate model experts will be needed to select the climate models which can provide a more plausible future. Since the big floods are rare events, simulation of long periods of climate, thence runoff, and are required to develop confidence in results. Since there will be competition at the big multipurpose reservoirs between flood control and other purposes, a thorough examination of the flood space relaxation criteria in the spring would be in order. Possibilities of basing part of the flood space requirements on weather forecasts should be tested.

It is anticipated that changes in water requirements of crops, wildlands, and landscaping will be gradual. Some monitoring of reference evapotranspiration by renovating or reinstalling a few of the lysimeters which were operating in the 1960’s is recommended to see if changes in the past 30 or 40 years are measurable. This would need to be a multi-year effort, possibly for 10 years, because of the variability from season to season.

While the evapotranspiration measurements are underway, it should be possible to convene a group or task force of knowledgeable experts on plant water consumption and agricultural practices by people from the university system and government. The goal would be to develop likely changes in evapotranspiration, and perhaps some ranges for year 2050 or 2100 scenarios, with warmer average temperatures and a higher carbon dioxide content of the atmosphere. To do this, some reasonable projections of future weather, including growing season precipitation are needed from the climate modelers. Some increase in plant water requirements would be expected because of warmer temperatures, but probably not a large percentage change.

The fifth major concern would be water temperature increases. There are existing models of water temperature which have been in use for a decade on some of the Sacramento River region major rivers. These models may need improvement as the job of maintaining suitable downstream temperatures becomes more difficult. Analysis of selected foothill reservoirs and rivers is suggested to see what a different pattern of inflow and higher air temperatures would do. New or upgraded temperature modeling is being developed as part of the Oroville power plant relicensing project. Once these tools are selected or developed, researchers can apply them to other streams and reservoirs. A logical extension would be to apply the new temperature models to evaluate the affect of a changed climate and runoff scenario, beginning with Lake Oroville and the Feather River.

The last item of strong interest would be effects of climate change in regions near California, especially the Colorado and Columbia River regions. The Colorado River would be most important to California because of potential impacts on water supply, with some potential effect on hydroelectric power. The Columbia River basin is an important source of electric power for California during the summer. If conditions there turned drier, there would be an impact on electricity as happened during 2001. For these basins, the best course of action for now may be to monitor results of anticipated new research and studies on runoff and water supply in both of these regions forthcoming by interested regional parties.
The preceding items are the major expected effects of global warming on the California water resources system. Climate change is just one of the factors water planners need to face in the coming century. Other factors include dealing with an expanding population, growth, environmental needs and maintaining the quality of land on water resources. Some degree of warming and sea level rise seem reasonably certain, but with the uncertainty of current climate model precipitation, the range of possible changes is quite large. There is serious scientific evidence that global warming will pose serious challenges to our water infrastructure. It is time to try to quantify the effects of projected climate change on California’s water resources. Being aware of potential climate changes should help in preparing better for an uncertain 21st century.
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California River Indices
California River Indices

Hydrology: California’s water development has generally been dictated by extremes of droughts and floods. The six-year drought of 1929-34 established the criteria commonly used to plan storage capacity or water yield of large Northern California reservoirs. The influence of climatic variability on California’s water supplies is much less predictable than the influences of geographic and seasonal variability, as evidenced by the recent historical records of precipitation and runoff. For example, the state’s average annual runoff includes the all-time low of 15 million acre-feet in 1977 and the all-time high of over 135 million acre-feet in 1983. Floods and droughts occur often, sometimes in the same year. The January 1997 flood was followed by a record-setting dry period from February through June, and the flooding of 1986 was followed by six years of drought (1987-92).

Figures showing the estimated annual unimpaired runoff of the Sacramento and San Joaquin River basins illustrate climatic variability. Because these basins provide much of the state’s water supply, their hydrology is often used as indices of water year classification systems.

Unimpaired runoff represents the natural water production of a river basin, unaltered by upstream diversions, storage, and export of water to or import of water from other basins.

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Sacramento River Runoff is the sum (in million acre-feet) of Sacramento River at Bend Bridge, Feather River inflow to Lake Oroville, Yuba River at Smartville, and American River inflow to Folsom Lake. The water year sum is also known as the Sacramento River Index, and was previously referred to as the “4 River Index” or “4 Basin Index”. It was previously used to determine year-type classifications under SWRCB Decision 1485.
San Joaquin River Runoff is the sum of Stanislaus River inflow to New Melones Lake, Tuolumne River inflow to New Don Pedro Reservoir, Merced River inflow to Lake McClure, and San Joaquin River inflow to Millerton Lake (all in million acre-feet).

Water Year Classification: Water-year classification systems provide a means to assess the amount of water originating in a basin. Because water-year classification systems are useful in water planning and management, they have been developed for several hydrologic basins in California. The Sacramento Valley 40-30-30 Index and the San Joaquin Valley 60-20-20 Index were developed by the State Water Resources Control Board (SWRCB) for the Sacramento and San Joaquin River hydrologic basins as part of SWRCB’s Bay-Delta regulatory activities. Both systems define one “wet” year classification, two “normal” classifications (above and below normal), and two “dry” classifications (dry and critical), for a total of five water year types.

Sacramento Valley Water Year Index = (0.4) x Current Apr-Jul runoff forecast (in million acre-feet) + (0.3) x Current Oct-Mar runoff (in million acre-feet) + (0.3) x Previous Water Year’s Index (if the Previous Water Year’s Index exceeds 10.0, then 10.0 is used).

This index, originally specified in the 1995 SWRCB Water Quality Control Plan, is used to determine the Sacramento Valley water-year type as implemented in SWRCB D-1641. Year types are set by first of month forecasts beginning in February. Final determination is based on the May 1, 50 percent exceedence forecast.
Frequency of a 100 Year Flood
Frequency of a 100-Year Flood

By Definition

Probability of a 100-year flood occurring in a given year = \( \frac{1}{100} \)

Therefore

Probability of a 100-year flood Not occurring in a given year = \((1 - \frac{1}{100})\)

Probability of a 100-year flood Not occurring in 30 years = \((1 - \frac{1}{100})^30\) = 0.7397

Therefore

Probability of a 100-year flood occurring at least once in the next 30 years = \(1 - 0.7397\) = 26%

Many Californians have a false sense of safety from floods, the result of incomplete information. Current flood threats are higher than commonly thought; the term “100-year flood,” for example, is misleading. It does not denote a flood that will occur only once every 100 years, as is commonly believed. Rather, it is the flood elevation (or flow) that has a one-percent chance of being equaled or exceeded each year. “Over the lifetime of a 30-year mortgage, there is a 26-percent chance of being flooded by a 100-year flood.”
Major Floods Since 1950
Major Floods Since 1950

Wet water years are not necessarily indicative of flood conditions. Although water-year 1983 was the wettest in California last century, major flooding did not occur. The following table shows estimated unimpaired runoff from a few of the state's larger floods since the 1950s. In January 1997, California confronted one of the largest and most extensive flood disasters in its history. Rivers from the Oregon border to the southern Sierra reached flood stages. Flood volumes of some rivers exceeded channel capacities by as much as 700 percent. In many major river systems, flood control dams reduced peak flows by one-half or more. Even so, leveed flood control systems were overwhelmed in some areas. Flood damage costs are nearing $2 billion.

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<th>Location</th>
<th>Date</th>
<th>Max 1-Day (cfs)</th>
<th>3-day Volume (taf)</th>
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<sup>a</sup> Impaired flows
Severity of Extreme Droughts in Sacramento and San Joaquin Valley
Severity of Extreme Droughts in Sacramento and San Joaquin Valley

Numerous multiyear droughts have occurred in California last century: 1912-13, 1918-20, 1922-24, 1929-34, 1947-50, 1959-61, 1976-77, and 1987-92. In order to provide water supply reliability, major reservoirs are designed to maintain and deliver carryover storage through several years of drought. The 1929-34 drought established the criteria commonly used to design the storage capacity and water yield of large Northern California reservoirs. Many reservoirs built since this drought were sized to maintain a reliable level of deliveries should a repeat of the 1929-34 hydrology occur. Even a single critical runoff year such as 1977 can be devastating to water users with limited storage reserves, who are more dependent on annual runoff. Following table compares the severity of recent droughts with the 1929-34 drought in the Sacramento Valley and San Joaquin Valley.

<table>
<thead>
<tr>
<th>Drought Period</th>
<th>Sacramento Valley Runoff</th>
<th>San Joaquin Valley Runoff</th>
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<tr>
<td></td>
<td>(maf/yr)</td>
<td>(% Average 1901-96)</td>
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<tr>
<td>1929-34</td>
<td>9.8</td>
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<tr>
<td>1976-77</td>
<td>6.6</td>
<td>37</td>
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<tr>
<td>1987-92</td>
<td>10.0</td>
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Groundwater supplies about 30 percent of California’s urban and agricultural applied water use. In drought years when surface water supplies are reduced, groundwater supports an even greater percentage of use, resulting in declining groundwater levels in many areas. For example, during the first five years of the 1987-92 drought, groundwater extractions exceeded groundwater recharge by 11 million acre-feet in the San Joaquin Valley. Drawing down groundwater reserves in drought years is analogous to reservoir carryover storage operations.
Infrastructure

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California’s Major Water Projects
California’s Major Water Projects
California Reservoirs
**California Reservoir Summary**

This table is a compilation of reservoirs in California with a gross storage capacity of 10,000 acre-feet or greater. Information given in the table is: location by Hydrologic Region, storage capacity, project uses, owner and year completed. Reservoirs are listed in reverse chronological order, with the most recently completed projects appearing first. The data came from the latest Bulletin 17-00, dated July 2000, titled “DAMS Within Jurisdiction of the State of California”. Several additional reservoirs that have been constructed since publication of Bulletin 17-00 have been added. Corrections have been made to the data where necessary, if published data is not current. Please note that storage values include dead storage, that is the reservoir capacity from which stored water cannot be evacuated by gravity.

### CALIFORNIA RESERVOIRS
(Over 10,000 AF Capacity)

NOTE: key to abbreviations used is at bottom of table.

<table>
<thead>
<tr>
<th>Reservoir (Dam) Name</th>
<th>Hydro. Region</th>
<th>Res. Capacity (TAF)</th>
<th>Project Uses</th>
<th>Owner</th>
<th>Year Comp</th>
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<td>Fresno Met. Flood C.D.</td>
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<tr>
<td>Tule Lake</td>
<td>SR</td>
<td>39</td>
<td>I</td>
<td>R</td>
<td>Lyneta Ranches 1904</td>
</tr>
<tr>
<td>Lake Hemet</td>
<td>SC</td>
<td>11</td>
<td>M</td>
<td>P</td>
<td>Lake Hemet MWD 1895</td>
</tr>
<tr>
<td>Dodge Res.(Red Rock #1)</td>
<td>SR</td>
<td>10</td>
<td>I</td>
<td>John Jay Casey</td>
<td>1893</td>
</tr>
<tr>
<td>Lake Chabot</td>
<td>SF</td>
<td>10</td>
<td>M</td>
<td>EBMUD</td>
<td>1892</td>
</tr>
<tr>
<td>McCoy Flat</td>
<td>NL</td>
<td>17</td>
<td>I</td>
<td>Lassen Irrig. Co.</td>
<td>1891</td>
</tr>
<tr>
<td>Crystal Springs (Lwr Crystal Sp)</td>
<td>SF</td>
<td>58</td>
<td>M</td>
<td>San Francisco</td>
<td>1888</td>
</tr>
<tr>
<td>Sweetwater</td>
<td>SC</td>
<td>28</td>
<td>M</td>
<td>South Bay ID(Sweetw't'r)</td>
<td>1888</td>
</tr>
<tr>
<td>Salt Springs Valley</td>
<td>SJ</td>
<td>10</td>
<td>IM</td>
<td>Rock Cr. W.D.</td>
<td>1882</td>
</tr>
<tr>
<td>San Andreas</td>
<td>SF</td>
<td>19</td>
<td>M</td>
<td>San Francisco</td>
<td>1870</td>
</tr>
<tr>
<td>French Lake</td>
<td>SR</td>
<td>14</td>
<td>IM</td>
<td>PR</td>
<td>Nevada ID 1859</td>
</tr>
</tbody>
</table>

**Total Storage (TAF)**: 35796 5562

**Total Number of Reservoirs**: 58 140

Symbol    | Project Uses & Special Notes
F          | Flood Control
I          | Irrigation Water
M          | Municipal &/or Industrial Water
P          | Hydropower
A          | Low Flow Augmentation or Fish Conservation
R          | Recreation
D          | Debris Dam
2          | Interstate Water Used Jointly
3          | Stores only Imported Colorado River Water

CALFED Bay-Delta Surface Storage Program Progress Report, April 2005
By California Department of Water Resources, U.S. Bureau of Reclamation, and California Bay-Delta Authority
FOREWORD

California’s population is growing by about 600,000 people a year, and forecasts indicate the State’s population could increase from about 36 million to roughly 48 million by 2030. As competition for limited water supplies intensifies, conflicts over how to allocate those supplies will worsen unless we change the way we manage our statewide water supply system. The CALFED Bay-Delta Program lays out the means for making fundamental improvement in the way we manage the system. These changes will allow for long-term water supply reliability, improvements in water quality, restoration of ecosystem and fishery resources, and leverage stability.

In one of the most ambitious integrated water management plans in the nation, the CALFED Bay-Delta Program set forth objectives and actions to protect water quality and at-risk species, restore habitat in the San Francisco Bay-Sacramento-San Joaquin River Delta (Delta) and continue to meet the water needs of farms and cities. The CALFED Bay-Delta Program recognized early on that its plan must include the means for more fully integrating California’s water supply system to provide more reliable water supplies and to meet competing needs. Specific potential storage projects are being carefully evaluated by the CALFED Bay-Delta program as one of the tools in California water resources management portfolio to help meet those needs.

We are now proceeding through the fifth year of implementation of the CALFED Bay-Delta Program, and the surface storage investigations have reached a critical milestone. With input from stakeholders and assistance from local agencies, the studies of the five surface storage projects identified in the CALFED Record of Decision (ROD) have advanced. The U.S. Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) have completed preliminary environmental impact studies and conceptual modeling scenarios based on general operational objectives. Now the studies must move toward a specific set of operational objectives to formulate detailed alternatives that can be used in decision-making processes.

Future efforts now hinge on the willingness of interested parties and stakeholders to participate and shape the alternative formulations that will be used to make decisions on these projects. A key Guiding Principle adopted by CALFED is to follow a benefits-based approach in developing cost allocations. The fundamental principle from the ROD is that costs, “to the extent possible, be paid by the beneficiaries of the program actions.” [ROD, page 34] Evaluations to date demonstrate that the surface storage projects have the potential to provide both broad public benefits and local/regional benefits. The next steps in the planning process will include identifying the specific public benefits that will be evaluated in more detailed studies and working directly with potential participants to assess their needs and interests in specific surface storage projects.

S U R F A C E  S T O R A G E  P R O G R E S S  R E P O R T

I N T R O D U C T I O N

This report, the second in a series of updates on the latest activities of the CALFED Storage Program, presents an overview of the major findings and status of each of the five storage studies. In addition, the report includes a comparable set of results from recent water supply reliability and water quality modeling. This modeling was performed using common model code and analysis protocols developed through the efforts of the Common Assumptions process. (For more about these teams, see the Developing Common Assumptions section under Common Considerations.)

The appendix contains brief descriptions of each of the studies, and a summary of accomplishments and analyses completed since the April 2004 storage progress report. Next steps for each of the studies are also described.

The intent of this second update is to:

• Provide information that will help potential project partners assess their interest in participating in the next steps of the storage investigations.
• Assist responsible agencies with decisions about future steps in the planning investigations for these projects.

M A J O R  F I N D I N G S  S I N C E  A P R I L  2 0 0 4

Following are the major findings of the five surface storage investigations since the first progress report, released in April 2004.

Table 1, Potential Primary Benefits of Surface Storage Projects, summarizes potential benefits of each project modeled to date. More detail of potential benefits are included in the summaries of findings for each project. A comprehensive set of results is included in the Interim Common Model Package, Modeling Protocol and Assumptions Technical Memorandum (available online at: www.storage.water.ca.gov/public_docs.cfm). These findings are general in nature, since the modeling scenarios are based on simplified operational objectives and assumptions. To define more specific operational objectives, Reclamation and DWR will work with interested parties to develop quantitative information about the timing and magnitude of deliveries or releases — along with other details — that would meet their water quality, fishery, ecosystem, and water supply needs. Table 2, Preliminary Capital Cost Estimates for The Surface Storage Projects, gives ranges of cost estimates for different project configurations.
### Table 1: Potential Primary Benefits of Surface Storage Projects

<table>
<thead>
<tr>
<th>Potential Benefit</th>
<th>Shasta Lake Water Resources Investigation</th>
<th>North-of-the-Delta Offstream Storage</th>
<th>In-Delta Storage</th>
<th>Last-Inspiring Reservoir Expansions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GW/CVP Water Supply</strong></td>
<td>Long-term average (TAF/year)¹</td>
<td>40–85</td>
<td>68–160</td>
<td>55–13</td>
</tr>
<tr>
<td></td>
<td>Or-Dec average (TAF/year)²</td>
<td>60–250</td>
<td>200–300</td>
<td>58–25</td>
</tr>
<tr>
<td><strong>EWA Water Supply</strong></td>
<td>Long-term average (TAF/year)</td>
<td>DNMM ³</td>
<td>8–124</td>
<td>14–20</td>
</tr>
<tr>
<td></td>
<td>Or-Dec average (TAF/year)</td>
<td>(EWA to be considered as a project objective in future studies)</td>
<td>(EWA water supply delivered to Delta-inefficient)</td>
<td>6–8</td>
</tr>
<tr>
<td><strong>Releases for Improving Delta Water Quality</strong></td>
<td>Long-term average (TAF/year)</td>
<td>DNMM ³</td>
<td>20–210</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Or-Dec average (TAF/year)</td>
<td>DNMM ³</td>
<td>120–137</td>
<td>3</td>
</tr>
<tr>
<td><strong>Water Quality Improvements</strong></td>
<td>Did not conduct chloride analysis</td>
<td>Did not conduct chloride analysis</td>
<td>4% to 25% (Change in average C loading to Delta P.P. for Jul-Oct (1978–1991) period)</td>
<td>58% to 50% (Change in Sep-Nov long-term average C delivered to SEB contractors)</td>
</tr>
<tr>
<td><strong>Water Supply for Rice Farming</strong></td>
<td>Long-term average (TAF/year)</td>
<td>DNMM ³</td>
<td>70–81</td>
<td>DNMM ³</td>
</tr>
<tr>
<td></td>
<td>Or-Dec average (TAF/year)</td>
<td>DNMM ³</td>
<td>8–27</td>
<td>DNMM ³</td>
</tr>
<tr>
<td><strong>Percent of Total Sacramento River at Pool Bridge exceeds 8°F Fahrenheit (Apr–Sept). Long-term</strong></td>
<td>3% to 7%</td>
<td>DNMM ³</td>
<td>DNMM ³</td>
<td>DNMM ³</td>
</tr>
<tr>
<td><strong>Early Life Stage Winter-run Salmon Mortality in Sacramento River</strong></td>
<td>Dry &amp; Critical Periods</td>
<td>0.3% to 1.4%</td>
<td>DNMM ³</td>
<td>DNMM ³</td>
</tr>
<tr>
<td><strong>Early Life Stage Summer-run Salmon Mortality in Sacramento River</strong></td>
<td>Dry &amp; Critical Periods</td>
<td>1% to 9%</td>
<td>DNMM ³</td>
<td>DNMM ³</td>
</tr>
<tr>
<td><strong>Net Increase in CVP Energy Production</strong></td>
<td>Long-term average (GWh/year)</td>
<td>18–40</td>
<td>DNMM ³</td>
<td>DNMM ³</td>
</tr>
<tr>
<td><strong>Reduction in Sacramento River Diversions (Apr–Aug)</strong></td>
<td>Long-term average (TAF/year)</td>
<td>DNMM ³</td>
<td>175–230</td>
<td>DNMM ³</td>
</tr>
<tr>
<td></td>
<td>Or-Dec average (TAF/year)</td>
<td>DNMM ³</td>
<td>115–255</td>
<td>DNMM ³</td>
</tr>
<tr>
<td><strong>Predominant Spring Flows for Cottonwood Establishment (Provided by Shasta through Coordination Operations)</strong></td>
<td>6-year average TAF/year</td>
<td>DNMM ³</td>
<td>3–460</td>
<td>DNMM ³</td>
</tr>
<tr>
<td></td>
<td>2 years out of 32 years</td>
<td>DNMM ³</td>
<td>3–120</td>
<td>DNMM ³</td>
</tr>
</tbody>
</table>

1. The range of benefits for each project reflects the various operational scenarios and storage options being investigated.
4. DNMM = Did Not Meet as a primary project objective.
TABLE 2: PRELIMINARY CAPITAL COST ESTIMATES FOR THE SURFACE STORAGE PROJECTS

<table>
<thead>
<tr>
<th>Project</th>
<th>Storage Capacity (TAF)</th>
<th>Capital Cost Estimate (in Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shasta Lake Water Resources Investigation</td>
<td>1,000</td>
<td>$200 - $400</td>
</tr>
<tr>
<td>North-of-the-Delta Offstream Storage</td>
<td>217</td>
<td>$1.200 - $2.200</td>
</tr>
<tr>
<td>In-Delta Storage</td>
<td>100 - 400 (range of</td>
<td>$1.000 - $1.300</td>
</tr>
<tr>
<td></td>
<td>expansion)</td>
<td></td>
</tr>
<tr>
<td>Los Vaqueros Reservoir Expansion</td>
<td></td>
<td>$900 - $1,200</td>
</tr>
<tr>
<td>Upper San Joaquin River Basin Storage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. There is a wide range of capital cost estimates due to the wide range of storage options, conveyance facilities, and appurtenant structures being studied. The cost estimates do not include pumping and operations and maintenance costs.
Expanding storage in Shasta Lake can increase the cold water available to maintain lower Sacramento River temperature and improve water supply reliability for other beneficial uses.

Raising Shasta Dam by 6.5 feet would enlarge Shasta Reservoir by 290 thousand acre-feet (TAF) and could improve the average annual water supply reliability by about 40 TAF/yr long-term and 60 TAF/yr during the driest periods.

Raising Shasta Dam by 18.5 feet would provide about 630 TAF of additional storage and could improve the average annual water supply reliability by about 85 TAF/yr long-term and 160 TAF/yr during the driest periods.

Model runs of three scenarios showed that raising Shasta Dam by 6.5 feet and 18.5 feet could also decrease the amount of time the river temperatures at Bend Bridge exceed 56 degrees between the April to September timeframe by approximately 3 and 7 percent, respectively. The 6.5 foot and 18.5 foot raises can also decrease mortality during the early life stage of spring run salmon in the upper Sacramento River during dry and critical periods by 1 percent and 9 percent respectively, and for winter run salmon by 0.3 to 1 percent, respectively.

### Table 3. Potential Primary Benefits of Shasta Enlargement

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(8.5 ft Raise) (Water Supply)</td>
<td>(10.5 ft Raise) (Water Supply)</td>
<td>(10.5 ft Raise) (Water Supply)</td>
</tr>
<tr>
<td>Total water supply (CVP/SWP)</td>
<td>Long-term average (TAF/year)</td>
<td>40</td>
</tr>
<tr>
<td>Drizst periods average (TAF/year)</td>
<td>90</td>
<td>120</td>
</tr>
<tr>
<td>Percent of time Sacramento River temperature at Bend Bridge exceeds 56°F (An-Sat)</td>
<td>Long-term</td>
<td>-3.0%</td>
</tr>
<tr>
<td>Early life stage salmon mortality in Sacramento River (winter run)</td>
<td>Dry &amp; critical</td>
<td>-2.3%</td>
</tr>
<tr>
<td>Early life stage salmon mortality in Sacramento River (spring run)</td>
<td>Dry &amp; critical</td>
<td>-2.5%</td>
</tr>
<tr>
<td>Net increase in CVP energy production (GWh/year)</td>
<td>Long-term average</td>
<td>10</td>
</tr>
</tbody>
</table>

Raising Shasta Dam by 6.5 feet could increase the long-term net CVP energy production by up to 10 gigawatt hours/year. Raising Shasta Dam by 18.5 feet could increase the long-term net CVP energy production by up to 40 gigawatt hours/year.

Results of the CALSIM II and DSM2 runs demonstrated that North-of-the-Delta Offstream Storage (NODOS) could provide improved water supply reliability for Sacramento Valley water users as well as SWP and CVP contractors; provide Level 4 water supply for Sacramento Valley wildlife refuges; provide water for rice straw decomposition in the Sacramento Valley; improve Delta water quality; reduce diversions from the Sacramento River during critical fish migration periods; contribute to Sacramento River ecosystem restoration objectives; and provide water and storage for the Environmental Water Account (EWA).

Modeling runs of four example scenarios showed that NODOS could provide an average annual total water supply benefit of 310 TAF to 470 TAF/yr long-term and 315 TAF to 440 TAF/yr during the driest periods. The total water supply benefits include water for the EWA. An average annual water supply of 124 TAF/yr long-term and 147 TAF/yr during the driest periods can be provided for the EWA. The quantity of water supply provided for EWA is limited by EWA's north of Delta purchase goals.

The average chloride loading at Banks Pumping Plant for July to October (1976–1991) varied between an increase of up to 4 percent and a decrease by as much as 27 percent, depending on the operational scenario.

With operational flexibility created by NODOS, diversions from the Sacramento River at Glenn-Colusa Irrigation District and Tehama-Colusa Canal intakes could be reduced during April through August by 170 TAF to 230 TAF/yr long-term and 115 TAF to 235 TAF/yr during the driest periods to protect fish migration.

Through coordinated operations of Sites and Shasta Reservoir, an average annual release of 120 TAF/yr long-term and during the driest periods could be provided from Shasta to maintain fall stability flows in the upper Sacramento River, and an average annual release of 460 TAF/yr could be provided in the spring of wet years to help improve cottonwood establishment in 8 years out of the 75-year simulation period.
TABLE 4. POTENTIAL PRIMARY BENEFITS OF NORTH-OF-THE-DELTA OFFSTREAM STORAGE

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1 (Water Supply)</th>
<th>Scenario 2 (Water Quality)</th>
<th>Scenario 3 (Environmental)</th>
<th>Scenario 4 (Environmental and EIM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(TAF/year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water supply (CVP/DWR)</td>
<td>Long-term average</td>
<td>200</td>
<td>113</td>
<td>228</td>
</tr>
<tr>
<td></td>
<td>Drift periods average</td>
<td>202</td>
<td>204</td>
<td>314</td>
</tr>
<tr>
<td>EWA water supply delivered to Delta inflow</td>
<td>Long-term average</td>
<td>DNIM</td>
<td>DNIM</td>
<td>DNIM</td>
</tr>
<tr>
<td></td>
<td>Drift periods average</td>
<td>DNIM</td>
<td>DNIM</td>
<td>DNIM</td>
</tr>
<tr>
<td>Water supply for rice straw decomposition &amp; Level 4 refuges</td>
<td>Long-term average</td>
<td>80</td>
<td>81</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>Drift periods average</td>
<td>20</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Release for improving Delta water quality</td>
<td>Long-term average</td>
<td>10</td>
<td>113</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Drift periods average</td>
<td>14</td>
<td>127</td>
<td>0</td>
</tr>
<tr>
<td>Total Water Supply Benefits</td>
<td>Long-term average</td>
<td>570</td>
<td>471</td>
<td>398</td>
</tr>
<tr>
<td></td>
<td>Drift periods average</td>
<td>435</td>
<td>443</td>
<td>314</td>
</tr>
<tr>
<td>Change in average chlorides leading to California Aqueduct for Jul-Oct (1976–96)</td>
<td>Long-term average</td>
<td>2%</td>
<td>-2%</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Drift periods average</td>
<td>2%</td>
<td>-2%</td>
<td>4%</td>
</tr>
<tr>
<td>Spring flows for cottonwood establishment (provided by Shasta through coordinated operations)</td>
<td>Long-term average</td>
<td>DNIM</td>
<td>DNIM</td>
<td>460 (provided in 8 out of 23 years)</td>
</tr>
<tr>
<td></td>
<td>Drift periods average</td>
<td>DNIM</td>
<td>DNIM</td>
<td>120</td>
</tr>
<tr>
<td>Provide fall stability flows below Kenneick for Oct.–Dec (provided by Shasta through coordinated operations)</td>
<td>Long-term average</td>
<td>DNIM</td>
<td>DNIM</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Drift periods average</td>
<td>DNIM</td>
<td>DNIM</td>
<td>120</td>
</tr>
<tr>
<td>Reduction in Sacramento River diversions (Apr–Aug)</td>
<td>Long-term average</td>
<td>175</td>
<td>224</td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>Drift periods average</td>
<td>184</td>
<td>225</td>
<td>121</td>
</tr>
</tbody>
</table>

DNIM — Did Not Meet as an objective in the scenario.
The In-Delta Storage Project (IDSP) could provide water supply reliability, operational flexibility, conjunctive use opportunities, water quality improvements, wildlife and habitat improvements and seismic stability.

Based on the Common Assumptions modeling criteria and the additional State Water Resources Control Board (SWRCB) Decision 1643 (D1643) requirements, average annual water supply benefits for the four operational scenarios vary from 77 TAF to 112 TAF/yr for the long-term and from 50 TAF to 64 TAF/yr during the driest periods. Other storage projects being studied for the CALFED Bay-Delta Program have not yet been assigned their own operational requirements similar to D1643 for IDSP. While final operational requirements would be unique to any particular storage proposal, it is interesting to note that the IDSP could deliver about 100 TAF/year additional average annual water supply benefits if it was not required to operate under the D1643 constraints.

Recent court decisions have put into question the water right permits issued by the SWRCB under water right Decision 1643. These conditions may change as a new water right decision is sought by the project proponent.

**TABLE 5. POTENTIAL PRIMARY BENEFITS OF IN-Delta STORAGE**

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Water Supply)</td>
<td>(W) (WQA)</td>
<td>(W) (WQA, and WPA)</td>
<td>(W) (WQA, and WPA)</td>
</tr>
<tr>
<td>TAF/yr</td>
<td>TAF/yr</td>
<td>TAF/yr</td>
<td>TAF/yr</td>
</tr>
<tr>
<td>Water supply (CP/SWP)</td>
<td>Long-term average</td>
<td>77</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Direct period average</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>EWA water supply delivered to San Luis Reservoir</td>
<td>Long-term average</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Direct period average</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td>Water supply for ERP actions</td>
<td>Long-term average</td>
<td>DNM</td>
<td>DNM</td>
</tr>
<tr>
<td></td>
<td>Direct period average</td>
<td>DNM</td>
<td>DNM</td>
</tr>
<tr>
<td>Release for improving Delta water quality</td>
<td>Long-term average</td>
<td>DNM</td>
<td>DNM</td>
</tr>
<tr>
<td></td>
<td>Direct period average</td>
<td>DNM</td>
<td>DNM</td>
</tr>
<tr>
<td>Total Water Supply Benefits</td>
<td>Long-term average</td>
<td>77</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Direct period average</td>
<td>64</td>
<td>61</td>
</tr>
</tbody>
</table>

DNM—Did Not Meet as an objective in the scenario.

The water quality data collected during the 2004 Upper and Lower Jones Tract flood indicates that the increase in organic carbon at Banks, Tracy, and Contra Costa intakes due to organic carbon contribution from Jones Tract is within the acceptable drinking water quality standards.
Completed operational studies show that the Los Vaqueros Expansion (LVE) project with 500 TAF of total storage could contribute to meeting the CALFED Bay-Delta Program’s water quality, water supply reliability and ecosystem restoration objectives while meeting the Contra Costa Water District (CCWD) participation principles. LVE could also meet the drought supply needs of agencies served by the South Bay Aqueduct (SBA).

A multi-purpose reservoir would provide maximum benefits if operated to provide water supply reliability benefits in very dry years, and provide EWA benefits in all years with the greatest quantities available in wetter years.

Through a combination of increased pumping from the Delta during periods of excess flow and a reduction in the need to blend in many years, an additional 189 to 249 TAF can be delivered, on average, during the 1928–34 and the 1986–92 droughts.

An average annual of 120 TAF/yr long-term, 47 TAF/yr during the driest periods, and 180 TAF/yr in wet years could be provided for the EWA by reducing pumping at Banks Pumping Plant while maintaining SWP deliveries to the SBA through releases from an expanded Los Vaqueros Reservoir.

LVE could allow better quality water (28 percent improvement in chloride concentration) to be delivered to the SBA in critical years during the winter and early summer months.

LVE could improve the delivered water quality to the SBA (by 60 percent in chloride concentration) in all water year types during late summer and early fall months.

### Table 6. Potential Primary Benefits of Los Vaqueros Reservoir Expansion

<table>
<thead>
<tr>
<th></th>
<th>Scenario 2 (Environmental Water/ SBA Water Quality)</th>
<th>Scenario 3 (SBA Water supply Reliability/Environmental Water/SBA Water Quality)</th>
<th>Scenario 4 (SBA &amp; CCWD Water Supply Reliability/ Environmental Water/ SBA Water Quality)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(TAF/year)</td>
<td>(TAF/year)</td>
<td>(TAF/year)</td>
</tr>
<tr>
<td>Total water supply (CVPI/SWP)</td>
<td>Long-term average</td>
<td>0</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td>Drought periods average</td>
<td>0</td>
<td>43</td>
</tr>
<tr>
<td>EWA water supply (TAF/year)</td>
<td>Long-term average</td>
<td>143</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td>Drought periods average</td>
<td>65</td>
<td>40</td>
</tr>
<tr>
<td>Total Water Supply Benefits</td>
<td>Long-term average</td>
<td>143</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>Drought periods average</td>
<td>65</td>
<td>66</td>
</tr>
<tr>
<td>Improvement in water quality</td>
<td>Long-term average</td>
<td>56%</td>
<td>52%</td>
</tr>
<tr>
<td>(chloride delivered to the SBA SWP)</td>
<td>Drought periods long-term</td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>Additional total water supply for</td>
<td></td>
<td></td>
<td>240</td>
</tr>
<tr>
<td>Bay Area users during a six-year drought (TAF)</td>
<td></td>
<td></td>
<td>180</td>
</tr>
</tbody>
</table>
Unlike the other four storage projects, studies for the Upper San Joaquin River Basin Storage Investigation (USJRBSI) have not yet considered the effect of Upper San Joaquin Storage operations on CVP/SWP operations in the Delta. The current version of CALSIM II does not dynamically represent Friant dam operations and how the CVP/SWP would adjust to changes in Friant operations. Evaluations presented in the Phase 1 Investigation Report, completed in October 2003, were limited to estimating the quantity of water supply that could be developed with additional storage. Once the CALSIM II model has been revised to dynamically represent Friant operations, CVP/SWP operational responses will be evaluated under multiple-purpose operational scenarios. These more detailed evaluations will be published in subsequent reports.

Previous study estimates described additional water storage benefits of 100 to 235 TAF/yr, depending on the storage scenario. Because the USJRBSI did not model the scenarios with the common model package, no modeling results table is included. The following is a description of the USJRBSI’s major findings since the publication of the first Progress Report:

- Southern California Edison (SCE) and Pacific Gas & Electric (PG&E) provided several options upstream of Redinger Lake to avoid impacts to their existing hydropower facilities. The study team has been evaluating these options. The options may provide a significant hydropower benefit, but appear to provide minimal water supply benefits.

- Estimating power generation and loss based on potential impacts and development of replacement power options to mitigate impacts has been a focus of recent studies. While no new net energy could be developed, one option may provide full replacement power.
COMMON CONSIDERATIONS AND NEXT STEPS

Most of the potential benefits for each storage project have been explored and described. Much of the work over the next year for the surface storage investigations will focus on defining more specific project alternatives, and conducting more refined analyses of the likely results under each alternative formulation. Three important considerations will be addressed as the work continues:

- Optimize the use of available and expected funding.
- Maintain consistent assumptions and comparable analytical methods between each project investigation to allow reasonable comparisons by decision makers.
- Define specific project formulations that best describe the potential local, State and Federal interest in these projects.

Funding

As one might expect in California’s current economic climate, there is some uncertainty as to the amount and timing of future funding for completing the surface storage investigations. This fact requires the surface storage investigation study teams to continue to monitor progress of the investigations and periodically reevaluate how to proceed given the expected availability of funds over the next several years. There is ample funding for the work scheduled for this year, but there are not sufficient dedicated funds to successfully complete all desired studies for all five projects.

California’s Proposition 50 provided State funding for surface storage investigations. In October 2004, the President signed the Water Supply Reliability and Environmental Improvement Act, Public Law 108-364, reauthorizing the CALFED Bay-Delta Program. PL108-364 reaffirms Federal feasibility study authorization for four of the five storage investigations (Shasta Lake Water Resources Investigation (SIWRI), NODOS, LVE, and USJRBS).

### TABLE 7. SURFACE STORAGE FUNDING TARGETS AND UNMET NEEDS

<table>
<thead>
<tr>
<th>Project</th>
<th>Funding Targets</th>
<th>Available Funding Sources (in Millions)</th>
<th>Unmet Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>State</td>
<td>Federal</td>
</tr>
<tr>
<td>North-of-the-Delta Offstream Storage</td>
<td>$14.30</td>
<td>$10.60</td>
<td>$ 3.50</td>
</tr>
<tr>
<td>Shasta Lake Water Resources Investigation</td>
<td>$10.40</td>
<td>$ 8.50</td>
<td>$ 4.50</td>
</tr>
<tr>
<td>Y-Delta Storage Investigations</td>
<td>$ 5.50</td>
<td>$ 5.50</td>
<td>$ 5.50</td>
</tr>
<tr>
<td>Los Vaqueros Reservoir Expansion</td>
<td>$20.50</td>
<td>$10.00</td>
<td>$ 4.00</td>
</tr>
<tr>
<td>Upper San Joaquin Storage Investigations</td>
<td>$13.00</td>
<td>$ 2.50</td>
<td>$10.50</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$86.80</td>
<td>$36.20</td>
<td>$13.50</td>
</tr>
</tbody>
</table>

1. Total remaining funding needed over the 10-year Plan.
2. Remaining Prop 50 funds available on Fiscal Year 2005 and beyond.
3. Includes Fiscal year 2005 appropriations and the President’s FY 2006 budget.
In December 2004, the California Bay-Delta Authority (Authority) approved a Finance Plan that includes funding and cost-sharing targets for each of the CALFED Bay-Delta Program’s elements. The Finance Plan spans ten years — 2005 through 2014. Table 7, adapted from the Final Finance Plan (January 2005), shows the funding targets for completing the five surface storage investigations, the current proposed division of available funding by project, and the unmet needs.

An estimated $29.2 million remains available from Proposition 50 bond proceeds to support surface storage investigations in the current fiscal year and beyond. The Federal budget for this fiscal year and the President’s proposed budget for next year amount to approximately $13.5 million, leaving an unmet need of $21.6 million. Any future Federal appropriations will reduce this need further.

Other efforts are underway to address uncertainties around future funding. DWR has prioritized its work efforts to focus resources on identifying the most viable projects and project tasks. DWR and Reclamation will work cooperatively to evaluate projects using information in the Federal Initial Alternatives Information Reports (IAIRs) and the other feasibility or environmental studies and reports. The Common Assumptions effort is developing information that will allow the projects’ performance, costs, and benefits to be compared using a consistent approach, and will inform decisions about ongoing project priorities.

In addition, DWR and Reclamation are working with stakeholders to identify which projects currently attract the greatest local interest along with a potential willingness to pay for some of the project costs. Based on the local interest expressed, the CALFED Storage Program plans to develop partnerships with stakeholders to define a set of specific plan formulations that show the most promise. If there are no willing partners for a particular project [demonstrating lack of interest in advancing a project] and/or the results of technical and economic studies indicate any of the five projects are not feasible in the near future, the State may decide to defer future studies of specific projects. If additional funds are not available in the future, one or more of the studies will likely be delayed or ceased to ensure that complete analyses can be done on the most promising projects.

4. With respect to federal funding for the entire CALFED Bay-Delta Program, Reclamation in a letter dated January 29, 2005, to the Authority, stated their concern over “the proposed cost allocations for projects identified in the [Finance] Plan not being consistent with current Federal law, and which may not be consistent with allocation proposed by Reclamation in the future.” Also, “...the estimates in the Plan far surpass the ceiling for new Federal appropriations authorized by the Act.” Reclamation stated it is committed to continue working with the Authority and the other CALFED agencies and stakeholders as we work through the difficult task of financing the Program.
Developing Common Assumptions

DWR, Reclamation, and the Authority initiated the Common Assumptions process to develop consistency and improve efficiency among the surface storage investigations. While each of the investigations addresses a unique purpose to meet different combinations of water supply and water quality needs, all of the surface storage investigations share some common requirements including completing planning reports and feasibility studies and the associated alternatives analyses to comply with the California Environmental Quality Act (CEQA), NEPA, and Clean Water Act Section 404 requirements. To complete the planning, environmental documentation and permitting process each project team through the Common Assumptions effort must:

- Define the CEQA (existing) and NEPA (future no-action) conditions
- Characterize likely impacts of the proposed project and alternatives
- Define and assess the cumulative impacts of the proposed projects when combined with other expected projects

The Common Assumptions teams have been developing a set of common tools and consistency protocols among the surface storage investigations. To date, the accomplishments of the Common Assumptions effort include:

- Developed CALSIM II and DSM2 (Progress Report Common Model Package) common baseline runs for use by the surface storage investigations to support this Progress Report. This is the first time that a common model package (including common tools, inputs, and assumptions) has been developed for use by the surface storage investigations. Prior to the Common Model Package, projects used different baseline runs and assumptions. For example, some projects assumed 8,500 cubic feet per second (cfs) capacity at Banks Pumping Plant while others assumed 6,680 cfs. For this report, all the investigations assumed 8,500 cfs capacity at Banks Pumping Plant.
- Developed consistent model structure and simulation steps that CALSIM II utilizes to analyze and apply the SWCRB D1485, D1641, Joint-Point-of-Diversion (JPoD), and the Central Valley Project Improvement Act (CVPIA) (b)(2) programs.
- Identified and resolved numerous technical and policy issues related to CALSIM II and DSM2 runs of project scenarios for supporting this Progress Report.
- Developed common reporting metrics for reporting CALSIM II and DSM2 model results. The common reporting metrics provide a basis for comparing or contrasting the performance of the storage projects.
- Initiated characterization of conservation, local supply projects, recycling, transfers, desalination, and conjunctive use for inclusion in future common model packages.
- Initiated review and upgrade of the Least Cost Planning Simulation Model (LCPSIM), an economics optimization model for urban water management options and the Central Valley Production Model (CVPM) and California Agricultural Production Model (CALAG), both agricultural economic models. The Economics and Cost Estimation Team will determine if these models should be used as the common economic models for the surface storage investigations.
The Common Assumptions effort has established a number of teams to address different areas required to develop consistency among the individual storage studies. Attaining consistency in modeling assumptions and analytical approach will allow the surface storage projects’ performance, costs, and benefits to be compared and will inform decisions about project prioritization. The Common Assumptions process also makes more efficient use of limited technical resources. The Common Assumptions teams provide:

- Development of technical tools and coordination of the use among the surface storage investigation study teams
- Briefings to the Bay-Delta Public Advisory Committee’s Water Supply Subcommittee (IWSS) and its technical representatives

Following is an overview of the Common Assumptions teams:

The **Core Team** comprises management representatives from DWR, Reclamation, and the Authority. This team provides overall direction to the common assumptions process.

The **Technical Coordination Team** is working on the refinement and development of common systems operations models including CALSIM II and DSM2. This team is focusing on the following areas:

- Consistent application of operations models
- Development of common systems operations reporting metrics
- Consistency in use of models and validation of consistency of modeling results
- Development of work plans and schedules for future common model packages
The **Economics and Cost Team** is working on the refinement and development of common economics models and cost estimation methodology. This team is currently focusing on the following areas:

- Review and refinement of the LCPSIM structure and assumptions; LCPSIM is an economics optimization model for urban water management options
- Review and refinement of other models if appropriate
- Compilation and comparison of engineering cost estimation guidelines from Reclamation, DWR, U.S. Army Corps of Engineers
- Consistent application of LCPSIM and CVPM, two agricultural production economic models
- Development of common economics and costs reporting metrics
- Review and update CVPM and CALAG

The **Characterization Team** is working on characterization and quantification of transfers, conservation, recycling, conjunctive use, and other local supply projects. This team is currently focusing on the following areas:

- Gathering information from agencies and water districts
- Translating information for incorporation into system operations and economics models
- Developing a broadly supported methodology for quantifying future conditions including future demands that represent potential changes in groundwater use, water transfers, and water use efficiency actions

The **Project Management Teams** apply common tools, methodology, and assumptions to analyses of individual projects.

The recommended strategy for the remainder of Stage 1 implementation is to continue the development of common assumptions by:

- Refining models in a series of logical steps, consistent with the surface storage investigation planning timelines (see Figure 2)
- Maintaining buy-in of project management teams
- Staging work to maintain study schedules for each of the individual storage projects
- Obtaining stakeholder review and input and seeking broad-based support for the technical approach, methods, and data

To complete development of common reporting metrics, three common model packages are defined based on updating data and information consistent with timing constraints. The Progress Report Common Model Package has been used for this report (see Figure 2). This package includes CALSIM II and DSM2. The next package, which is planned to be available in Fall 2005, will be the Plan Formulation Common Model Package. It will include characterizations of CALSIM II, DSM2, LCPSIM, CVPM and a method for linking them.

The final package, planned to be available in Winter 2007, is the Feasibility Common Model Package. It will be used for the feasibility analysis and NEPA/CEQA environmental documentation and include the models identified above, and possibly others.
Defining Specific Project Alternatives

One of the next key steps in the surface storage planning process is to define specific project alternatives that meet the requirements of Federal, State, and local participants. Formal project alternative definitions require identifying and solving specific problems and needs. To date, Reclamation and DWR have developed an array of informative modeling scenarios for the five surface storage investigations. To develop project alternatives, additional detail will be needed to describe the specific goals of potential Federal, State, and local participants.

The CALFED Storage Program is refining project alternatives and evaluating the level of potential participants’ interests. The Federal planning process is being used to determine if a Federal interest exists for a specific project. (Federal interest is defined as whether a commitment of Federal resources will contribute to the overall benefit of the Nation.) This process includes preparing up to three reports (the Initial Alternatives Information Report, Plan Formulation Report, and Federal
Feasibility Study Report). Each subsequent report increases in detail and specificity to determine if a workable solution to identified problems and needs can be developed and implemented. The Federal Feasibility Study includes an iterative planning and decision making process that documents decisions and recommends a specific plan to Congress for implementation. The Federal Feasibility Study includes technical studies, a benefit and cost analysis, cost allocation estimates, non-Federal sponsor commitments, and preparation of a planning report and appropriate environmental compliance documentation.

Reclamation and DWR have completed the 1AIR for SEWRP, and have initiated the 1AIRs for NODOS, LVE, and USJRBSS. DWR has also completed a Draft State Feasibility Study for ISDP. However, to complete feasibility analyses for each project, alternatives that include the interests of all participants must be evaluated.

Results from initial investigations strongly suggest that additional surface storage can contribute to broad public benefits in several ways. More specific descriptions of these public objectives and benefits will be explored with other State and Federal resource agencies during the coming year. In addition, Reclamation and DWR are working directly with potential participants by performing studies requested by potential participants and are providing information to potential participants as they perform their own evaluations to determine if the surface storage projects can contribute to meeting their specific water resource needs. This Progress Report is intended to serve as a guide to help potential participants learn more about how the five projects might serve their specific urban, agricultural, environmental water supply and water quality needs.

Reclamation and DWR have begun formal environmental documentation on three of the projects (NODOS, ISDP, and USJRBSS). These reports are being prepared concurrently with the Federal planning process. However, until alternatives are defined, detailed impact analyses cannot be completed. The next steps in the planning process will include identifying each surface storage project’s broad public benefits and working directly with potential participants to assess their needs and interests in specific surface storage projects. As progress is made in these two areas, more detailed impact analyses will proceed.
PROJECT SPECIFIC CONSIDERATIONS

Shasta Lake Water Resources Investigation

A critical issue for the SLWRI is the potential for additional impacts to the McCloud River. Current State law, Public Resources Code 5093.542 (c), allows DWR to conduct technical and economic studies of the McCloud River basin; however, no other State agency can participate in a project that has “an adverse effect on the free flowing condition of the McCloud River” upstream of the McCloud River Bridge or “its wild trout fishery.” Shasta Lake, when full, already inundates the river upstream of the McCloud River Bridge. Preliminary estimates show that a 6.5-foot raise of Shasta Dam would inundate the McCloud River an additional 1,400 feet. Reclamation will evaluate further the potential environmental effects on the McCloud River associated with a Shasta Dam raise and will document the findings in the feasibility report and environmental compliance documents. DWR will continue to participate in the SLWRI to the extent allowed by the Public Resources Code.

Sites of cultural significance exist in and around Shasta Lake, many related to historic activities of indigenous peoples. Both Native American and non-Native American burials from known burial sites and cemeteries were re-interred to cemeteries during the construction of Shasta Dam. This was done with permission of the descendants and they determined where the remains were to be re-interred. The Winnemem band of the Wintu Indians have expressed concern relating to sites of significance to the Winnemem that are within the existing gross pool of Shasta Lake and several possible sites would be impacted by raising the dam. The Winnemem have alluded to approximately 20 sites being within the 18.5 feet raise. Although the Winnemem band of the Wintu Indians are currently not a federally recognized tribe, identifying these sites and developing appropriate mitigation measures will be a major focus in the feasibility study.
North-of-the-Delta Offstream Storage

There is considerable stakeholder interest to evaluate the flow regime of the Sacramento River and potential relationship to NODOS, where flow regime includes the magnitude, duration, timing and subsequent effects of flows in the river. The possibility of modifying flows to improve water supply reliability, water quality and simultaneously benefit the environment will be evaluated. Topics that will be considered related to potential high flow diversions associated with NODOS include Sacramento River geomorphology, meander migration and ecosystem development.

The NODOS project management team requested that a Sacramento River flow regime technical advisory group (to include local, State, and Federal resources agencies as well as university scientists and environmental advocates and scientists) be formed to consider the flow regime of the upper Sacramento River. The Sacramento River Technical Advisory Group (TAG) was formed in early 2002 and was tasked to help identify potential NODOS flow regime impacts and benefits, as well as improve the general understanding of the flow regime of the upper Sacramento River and related ecosystem processes. Meetings of the Flow Regime TAG began in 2002. An administrative draft Sacramento River Flow Regime Technical Advisory Group Summary Report and Evaluation was prepared for review by the TAG and NODOS project management team. The report documents discussions of the TAG meetings and summarizes the findings of recently completed and ongoing studies to improve the ecosystem along the Sacramento River between Keswick and Colusa. The report also describes historic changes in the flow regime of the Sacramento River and concepts that may improve the ecosystem habitat both with and without NODOS. Finally, the report documents the need for additional studies related to flow regime and ecosystem processes.

The NODOS team is currently incorporating comments from the TAG and NODOS project management team to finalize the Sacramento River Flow Regime Summary Report and Evaluation. Findings in the report will assist in the evaluation of the project alternatives and operational plans are developed. (Information from the report will help evaluate the potential benefits and adverse impacts to the upper Sacramento River system.) A flow regime work plan that includes a list of proposed analytical tools to address flow regime issues related to the diversion of flows into NODOS is being developed. The work plan and the Sacramento River Flow Regime Summary Report and Evaluation report will be submitted to a CALFED Science Panel for review in 2005.
In-Delta Storage Project

Resolution of the water quality issue related to the effect of organic carbon (OC) on drinking water quality is the main challenge of the IDSP. The potential sources of nutrients influencing Delta water quality are peat, algae, aquatic plants, seawater intrusion and seepage returns. Also, salinity, in particular bromide, a constituent of seawater, affects urban water agencies’ ability to meet U.S. Environmental Protection Agency’s safe drinking water regulations. Impact of releases on water temperatures and dissolved oxygen (DO) in Delta channels adjacent to the proposed outlets is of concern related to the fisheries habitat.

The Proteus Disposal Agreements (PDAs) executed by Delta Wetlands Properties with California Urban Water Agencies (CUWA), CCWD, and East Bay Municipal Utility District (EBMUD) include a Water Quality Management Plan which prevents the release of IDSP water that will degrade the water quality and beneficial uses of Delta water. The PDA with CCWD protects Delta water quality by restricting diversions and discharges from the proposed reservoirs. The terms and conditions of these PDAs have been incorporated into the State Water Resources SWRCB D1643, but the PDAs themselves are independent agreements that apply to Delta Wetlands Properties and its successors. Measures to avoid and mitigate operational impacts will be developed in consultation with CUWA, CCWD, and EBMUD as operational plans are developed. Circulating fresh water through the reservoirs could resolve the OC, DO, and temperature related issues. New water treatment technology using oxidation is under development. This technology may eliminate the OC concerns if the technology becomes available.

The 2001 and 2002 Bay-Delta CALFED In-Delta Storage Science Panel Reviews emphasized the need for field experiments to study the OC, DO and temperature variations under simulated natural processes. With a recent levee breach on Upper Jones Tract, two islands neighboring Bacon Island (Upper and Lower Jones Tract) were flooded. DWR has monitored water-quality of the flooded islands and at the Banks, Tracy, and CCWD’s Old River Rock Slough and Los Vaqueros intakes. The next stage of work is to use the data resulting from the monitoring as input to the CALSIM II and DSSM2 models and to analyze impacts of releases from the Bacon Island and Webb Tract proposed reservoirs on drinking water quality.
Los Vaqueros Reservoir Expansion

DWR and CCWD are continuing discussions on forming a Joint Powers Authority (JPA) aimed at establishing a CEQA lead for the project.

Reclamation is also integrating the LVE into the CALSIM II model so interactions between projects or groups of projects can be evaluated.

On March 16, 2003, the Central Delta Water Agency challenged the SWRCB and the water right permit issued to Delta Wetlands. The Appellate Court found the SWRCB decision and water right permit were not prepared in accordance with law and therefore voided the permit (Central Delta Water Agency v. State Water Resources Control Board, (Case No. C041749) November 19, 2004). The California Supreme Court denied review of the Appellate Court decision. Delta Wetlands would need to file a petition to the SWRCB to change the water right application to address the issues raised by the Appellate Court in vacating the permit. The major issue raised by the court was failure to identify the buyers of the water and where it will be used. Other issues include ensuring that the CEQA analysis covered the effects of the use of project water and that the permit assures that protection of water quality is addressed. The SWRCB petition process would include the opportunity for interested parties to file protests, and a hearing to address any unresolved protests. Delta Wetlands would need to supplement its environmental documentation to add information on where the water will be used and any effects, such as growth inducing impacts.
Upper San Joaquin River Basin Storage Investigation

In August 2004, the U.S. District Court found that Friant Dam has been operated in violation of California Fish and Game Code Section 5937, which requires that water be released from the dam to maintain a river's historic fishery. The ruling specified that a remedy to the violation be determined at a later date. While a future remedy ruling may influence the downstream use of water supply, it is recognized that a remedy to the violation is very complex and may take several years of study. Therefore, it would be speculative to consider the implications of any potential downstream releases at this point in the USRBSI. The U.S. District Court – Eastern District of California has issued an order that states the court’s intentions to complete a decision on this issue including the remedy phase by May 1, 2006.

The study team will continue, cognizant of the ongoing litigation, and will proceed based on the current Friant Dam operating criteria and the ROD objectives. The study team will continue evaluating storage options to contribute to restoration of and improve water quality for the San Joaquin River and facilitate conjunctive water management and water exchanges that improve the quality of water deliveries to urban communities.

DWR and Reclamation are continuing to work with local water agencies, environmental groups, and local stakeholders to advance the development of a scientifically-based restoration plan that is balanced with water supply needs. In addition, several agencies and interest groups are also developing restoration plans. Consensus on a feasible and acceptable plan has not been reached and will not likely be reached for several years. For the purpose of describing the expected ecosystem benefits of the USRBSI, several alternative restoration plans may need to be evaluated and the benefits described for each.

Summary

The work done to date has described the broad array of potential benefits that each storage project can provide. The next steps require each project team to get more specific about which of the possible project benefits are most needed from a Federal, State, and local perspective. Then the refined project formulations will be evaluated to describe the physical benefits that can be produced. Once the physical benefits are described, the next step will be to compare the expected benefits to the cost of building and operating the project.
APPENDIX

CALFED STORAGE PROGRAM
STATUS OF THE FIVE SURFACE STORAGE INVESTIGATIONS

Shasta Lake Water Resources Investigation

Study Description

Reclamation re-initiated a feasibility investigation in 2000 to evaluate the potential to enlarge Shasta Dam primarily for increased water supply reliability and water quality improvements for anadromous fish survival, with the potential to consider limited hydropower generation and flood damage reduction. This investigation is being conducted under the general authority of Public Law 96-375 (1980).

The ROA provided further guidance for the feasibility investigation by identifying the potential for expansion of Shasta Reservoir to increase the pool of cold water available to maintain Sacramento River water temperatures for anadromous fish and provide other water management benefits such as water supply reliability.

Accomplishments

- Completed Initial Alternatives Information Report in June 2004
- Conducted Public Workshop in August 2004
- Continued with ongoing public, tribal and stakeholder outreach

Analyses Completed

Technical studies of initial alternatives are continuing. Studies include systems modeling, fisheries studies, environmental surveys, engineering, and economics.

Next Steps

Reclamation will be issuing a Notice of Intent in spring 2005, initiating the NEPA process. The schedule for planning documents follows:

- Summer 2005 — Conduct scoping meetings and release Scoping Report
- Fall 2006 — Release Plan Formulation Report
- Fall 2008 — Release Final Feasibility Study Report and EIS
**Surface Storage Progress Report**

**North-of-the-Delta Offstream Storage**

**Study Description**

As directed by the ROD, DWR and Reclamation formed a partnership (in November 2000) with local water interests and other State and Federal agencies to investigate offstream storage north of the Delta. Under the NODOS investigation, DWR and Reclamation, in coordination with the partnership, are formulating a range of alternatives, including Sites Reservoir and Newville Reservoir and associated source and conveyance options.

The objectives identified in the ROD include enhancing water management flexibility in the Sacramento Valley while reducing water diversions from the Sacramento River during critical fish migration periods; increasing reliability of supplies for a significant portion of the Sacramento Valley; and providing storage and operational benefits for other CALFED programs including Delta water quality and the EWA.

**Accomplishments**

- Completed and distributed the administrative draft *Sacramento River Flow Regime Summary Report and Evaluation report to the Flow Regime TAU and NODOS Project Management Team for review*
- Completed biological and cultural resources field studies
- Completed draft descriptions of the affected environment for the *Environmental Impact Report/Environmental Impact Statement (EIS/EIR)*
- Completed feasibility engineering study on reverse flow facilities for releasing water back to the river
- Completed feasibility engineering studies on dams and appurtenant structures, conveyance facilities, and road relocations
- Completed a probable maximum flood analysis and a dam break analysis

**Analyses Completed**

Since the April 2004 Progress Report, the Common Assumptions Progress Report Common Model Package was used to provide updated CALSIM II and DSM2 modeling output for the four NODOS operational scenarios. These scenarios are preliminary options and are not considered alternatives.

**Next Steps**

The NODOS team is working on establishing partnerships with potential project participants to define potential project formulations and operations. Defining the project formulations will require development of a purpose and need statement that meets statutory requirements and encompasses potential project participants’ interests. Once the project purpose has been defined, alternatives can be formulated to meet that purpose and serve the specific needs. With the development of project alternatives, the NODOS team will complete the evaluation of project benefits and environmental impacts. The schedule for NODOS planning documents follows:

- **Summer 2005** — *Release Initial Alternatives Information Report*
- **Summer 2006** — *Release Plan Formulation Report*
- **Fall 2006** — *Release Draft Feasibility Study Report and EIS/EIR*
- **Fall 2007** — *Release Final Feasibility Study Report and EIS/EIR*
The IDSP would provide capacity to store approximately 217 TAF of water in the south Delta for a wide array of water supply, water quality and ecosystem benefits. The project would include two storage islands (Webb Tract and Bacon Island) and two habitat islands (Holland Tract and Bouldin Island), similar to that proposed by Delta Wetlands over a decade ago, but would also include:

- New embankment design
- Consolidated inlet and outlet structures
- New project operations
- Revised Habitat Management Plans

DWR completed the Draft State Feasibility Study and released the Draft Executive Summary Report for the IDSP for stakeholder and public reviews in February 2004. These reviews indicated the need for further analysis of the water quality, risk of failure, operations and economic viability of the project.

The IDSP could provide a variety of benefits and contribute to meeting each of the CALFED Bay-Delta Program's four objectives for water supply reliability, water quality, ecosystem restoration, and levee system integrity. The project could meet the water supply and operational flexibility needs of the State Water Project and the Central Valley Project.

The IDSP's strategic location within the Delta provides enhanced operational flexibility of the CVP and SWP in responding to short-term operational needs for water quality and fisheries benefits. This added flexibility and more immediate response would result in greater environmental protection and more reliable water supplies. The IDSP could help reduce salinity intrusion by making releases of fresh water into the Delta. It could improve export water quality by storing water when Delta inflow quality is good and salinity is low. The IDSP could provide water needed to support the EWA, enhancing EWAs ability to respond to real-time fisheries needs. Releases from the IDSP could help provide spring pulse flows proposed in the Ecosystem Restoration Program (ERP). The IDSP could also provide additional water quality and aquatic habitat improvements by strategically releasing carryover water saved in island storage. The IDSP could provide water for supplies (in addition to Level 2 refuge supply) to meet CVPIA Level 4 refuge demand. Meeting this demand more reliably would benefit fish, wildlife, and associated habitats in the Central Valley. Wildlife habitats would be improved and protected by developing terrestrial, aquatic, and wildlife-friendly agricultural habitats on Holland Tract and Bouldin Island.

The embankments would withstand higher magnitude earthquakes compared to existing levees, reducing the chance of embankment failure and associated saltwater inflow from the Bay. In case of a seismic failure of adjoining islands, the reservoirs could release fresh water to repel salt water.

There is a need to enhance public recreation within the Delta. The proposed reservoir and habitat islands could provide more public recreation in the Delta. Recreational opportunities could include hunting, fishing, hiking, biking, and interpretative experiences and have a positive effect on local economy.
Accomplishments

- Completed and released the State Draft Feasibility Study and the Draft Executive Summary, along with supporting study reports in February 2004
- Conducted two public workshops. Stakeholder comments were received during the 45-day public review period and highlighted the need for further investigations of the water quality, risk, operations and economics issues
- Collected the Year 2004 Upper and Lower Jones Tract flooding information on property damages, water quality, and seepage to adjacent islands for use in future evaluations
- Continued with technical studies of risk, design, operations, water quality, environmental impacts, benefits, and costs by following the common assumptions process to assure that the analyses use a consistent basis for comparison, and that the planning assumptions are based on the most current rules, regulations, and operations

Analyses Completed

The Common Assumptions Progress Report Common Model Package was used to provide updated CALSIM II and DSM2 modeling output for the four IDSP operational scenarios. The Draft Feasibility Study released in February 2004 had three scenarios dealing with water supply, EWA and ERP needs. A fourth scenario for Delta water quality improvement was added.

Next Steps

The following studies are continuing and results will be reported in a Supplemental Report.

The next stage of investigations will use the Jones Tract flooded islands, and Banks, Tracy, and CCWD intake monitored water quality data as input to the CALSIM II and DSM2 models and analyze impact of releases from Bacon Island and Webb Tract proposed reservoirs on the drinking water quality.

Reservoir operations with common baseline assumptions and water circulation for improvement of quality will be developed using the new structural locations.

Information on risk analysis presented in the February 2004 State Draft Feasibility Study will be updated by including damages to property, crops and infrastructure resulting from Jones Tract flooding.

Economic models are being reviewed for characterization of water management options, including agricultural and urban conservation, wastewater recycling, desalination, local conjunctive use or other water supply projects, and water transfers, affecting model inputs for water supplies and demand. A refined version of these models will be used for an updated economic analysis for the project.

DWR will begin discussions on joint partnerships with interested stakeholders after the supplemental feasibility report release.

In April 2005, DWR will finalize a Supplemental Study Report including information on further analysis of issues identified during the 2004 Public Review. This report, together with an assessment of interest in the project from potential participants, will be used to consider if additional work on the In-Delta Storage Project is warranted at this time. If a decision is made in June 2005 to move forward with an environmental review of the project, the following schedule is proposed:

- **July 2005** — Initiate supplemental environmental documentation process
- **December 2005** — Formulate a Project Plan acceptable to stakeholders and release a State Plan Formulation Report
- **Summer 2006** — Release Draft Supplemental Environmental Documentation
- **Winter 2006** — Release Final Supplemental Environmental Documentation
Los Vaqueros Reservoir Expansion

Study Description

The existing Los Vaqueros Project was completed in 1998 to provide 100 TAF of offstream water storage to improve water quality and provide emergency storage for CCWD customers. Water is diverted from the Delta at the existing Old River pump station when Delta water quality is good and impact to Delta fisheries is low and pumped to the Los Vaqueros Reservoir for storage.

The LVE could provide up to 500 TAF of offstream storage to CCWD and other Bay Area water agencies. New Delta intakes, pumps, and pipelines would be required to fill the new reservoir capacity, and water deliveries would be made from the expanded reservoir to Bay Area beneficiaries through new conveyance facilities.

There are three planning objectives for the LVE:

- Improve Bay Area water quality
- Improve Bay Area water supply reliability
- Protect and restore at risk Bay-Delta fish populations

Accomplishments

- Initiated development of an IAIR in September 2004
- Continued to work with Bay Area potential partners on assessing dry-year needs for imported water and potential shortfalls

Surf ace Storage Progress Report

- Initiated the CALSIM II integration of the expanded facility to provide a tool to evaluate the dynamic interaction between LVE and the Federal and State water systems and other proposed CALFED storage projects
- Initiated development of a JPA between DWR and CCWD for the purposes of establishing a lead agency for CEQA and developing an advisory committee agreement with the SBA water agencies

Analyses Completed

Preliminary hydrologic and water quality modeling has been completed using the new common assumptions baseline for three of the projects potential operating scenarios.

Next Steps

Reclamation, working in coordination with DWR and CCWD, has begun the development of an IAIR needed to describe the formulation of initial alternatives to address planning objectives established for the LVE study. The document will identify a range of initial alternatives that address the Federal, State, and local water resources and environmental needs. The schedule for these studies follows:

- Summer 2005 — DWR and CCWD will determine what agency will be the CEQA lead for the project and if the formation of a JPA is necessary for the CEQA lead
- Summer 2005 — Issue a Notice of Preparation/Notice of Intent (NOP/NOI) for environmental documentation and scoping studies
- Summer 2005 — Release Initial Alternatives Information Report
- Spring 2006 — Release Plan Formulation Report
- Winter 2007 — Release Final Feasibility Study Report and EIR/EIS
Upper San Joaquin River Basin Storage Investigation

Study Description

The ROD recommended evaluating increasing water storage in the upper San Joaquin River basin at Millerton Lake by raising Friant Dam or developing a functionally equivalent storage program. The new water supply developed with additional storage could contribute to restoration of and improved water quality for the San Joaquin River and to facilitate additional conjunctive management and exchanges that improve the quality of water deliveries to urban areas. Other benefits could include hydropower production and flood control. In 2003, Reclamation received authority to undertake a feasibility study of Upper San Joaquin River storage projects.

Friant Dam is currently operated to supply water to agricultural and urban areas in the eastern San Joaquin Valley and to provide flood protection to downstream areas. Millerton Lake, the largest reservoir in the upper San Joaquin River basin, has a storage capacity of 320.3 TAF. Because the minimum storage for canal diversion is about 130 TAF, the maximum active conservation storage is about 390.5 TAF.

Accomplishments

• Completed the NEPA scoping process. A Scoping Report summarizing the major issues and comments received was released to the public in December 2004
• Continued with public, tribal, and stakeholder outreach including a July 2004 Public Workshop
• Established Cooperating Agency groups, developed a Memorandum of Agreement (MOA) and invited sixteen agencies as Cooperating Agencies for participation on technical teams

Analyses Completed

The USJRB SI has continued with technical studies including hydropower, engineering, water operations, flood benefits, and costs of potential options that will be documented in the IAIR and appendices. Screening criteria are also being developed and will be used to select surface storage options that would serve as a basis for the formulation of storage alternatives. The USJRB SI is also considering groundwater storage options. Stakeholder interviews were conducted to receive input on conjunctive management opportunities and issues in the region.

Next Steps

The most immediate step is to secure the signature of sixteen agencies proposed as Cooperating Agencies. MOAs have been sent to the agencies requesting their participation on technical teams to assist with development of a feasibility study report and EIS/EIR.

The next major milestones in the USJRB SI planning process are to complete the alternatives development and screening, perform detailed evaluation of the alternatives, and select a preferred alternative. As with all the surface storage projects, meeting the following schedule depends on the availability and timeliness of State and Federal funding:

• Spring 2005 — Release Initial Alternatives Information Report
• Summer 2005 — Release Plan Formulation Report
• Summer 2008 — Release Draft Feasibility Study Report and EIS/EIR
• Summer 2009 — Release Final Feasibility Study Report and EIS/EIR
List of Abbreviations

Authority . . . . California Bay-Delta Authority
Bay-Delta . . . . San Francisco Bay-Sacramento-San Joaquin River Delta
CALAG . . . . California Agricultural Production Model
CALFED . . . . A collaborative effort of over 20 State and Federal agencies to develop and implement a long-term comprehensive plan to restore the ecological health and improve water management for beneficial uses of the Bay-Delta system
CALSIM II . . . . Generalized water resources simulation model for simulating the operations of the State Water Project/Central Valley Project system
CCWD . . . . Contra Costa Water District
CEQA . . . . California Environmental Quality Act
cfs . . . . Cubic feet per second
CUWA . . . . California Urban Water Agencies
CVP . . . . Central Valley Project
CVPIA . . . . Central Valley Project Improvement Act
CVPM . . . . Central Valley Production Model
Delta . . . . Sacramento River-San Joaquin River Delta
DO . . . . Dissolved Oxygen
Hydropower Projects Relicensing
Hydropower Projects Relicensing

The Federal Energy Regulatory Commission administers a program of licensing nonfederal hydroelectric power plants. FERC licenses establish conditions on the owners’ operation of their plants; typical conditions include instream flow requirements and other fishery protection measures. Licenses for many California hydropower plants will be coming up for renewal soon. The relicensing process affords resource agencies and individuals the opportunity to seek changes in instream flow requirements, such as those suggested in Central Valley Project Improvement Act’s draft Anadromous Fish Restoration Program. Hydropower generation is a nonconsumptive water use, but changes in the amount and timing of water diverted for power generation can affect other uses downstream. The impact of deregulation of the electric power industry on relicensing decisions is uncertain. Current owners of some generating facilities, especially smaller plants, may sell their generation assets in response to deregulation.

Water supply impacts of relicensing are difficult to quantify, in part because impacts are site-specific. Some plants subject to relicensing, for example, currently have no bypass flow requirements. It is likely that relicensing would establish bypass flows at these sites. Other plants subject to relicensing already have substantial bypass flows, and it is not clear what changes relicensing would bring.

### CA. Hydropower Projects - License Years 2000 - 2010 (projects over 1,000 kW)

<table>
<thead>
<tr>
<th>License Expiration Date</th>
<th>Project</th>
<th>Stream</th>
<th>Licensee</th>
<th>Capacity (1,000 kW)</th>
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<tr>
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<td>SCE</td>
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<td>Mono Creek</td>
<td>SCE</td>
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<td>North Fork Feather River</td>
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Landscape Water Use

Urban Landscape Evapotranspiration
By Richard L. Snyder, University of California, Davis,
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Urban Landscape Evapotranspiration

By Richard L. Snyder, University of California, Davis, and Simon Eching, DWR
Urban Landscape Evapotranspiration
By Richard L. Snyder\textsuperscript{1} and Simon Eching\textsuperscript{2}, April 2005

Irrigation controllers are now widely used to manage landscape irrigation; however, scientifically based information on when to apply water and how much to apply is limited. In California, the landscape industry is huge and there is increased competition among water users. Consequently, managing irrigations to optimize efficient water use is critically important to stretch existing water supplies. The University of California and California Department of Water Resources have developed an Excel program “LIMP.XLS” to help landscape professionals and homeowners to calculate $ET_o$ rates, determine landscape coefficient ($K_L$) values, estimate landscape evapotranspiration ($ET_L$) and determine irrigation schedules. This program not only helps practitioners but it also clarifies what horticulturalists need to research to help to improve urban irrigation management.

Evapotranspiration from landscape vegetation is estimated using a regional measure of evaporative demand (i.e., reference evapotranspiration or $ET_o$), a microclimate coefficient ($K_m$) to adjust the $ET_o$ for the “local” microclimate, a vegetation coefficient ($K_v$) that accounts for the difference in ET between well watered vegetation and the local $ET_o$, a density coefficient ($K_d$) that adjusts the ET estimate for plant density, a stress coefficient ($K_s$) that adjusts for reductions in ET due to water stress and an evaporation coefficient ($K_e$) that defines a baseline coefficient value. The landscape coefficient ($K_L$) to estimate landscape ET ($ET_L$) is estimated as

$$K_L = K_m \times K_v \times K_d \times K_s > K_e.$$  

Then the landscape evapotranspiration ($ET_L$) is computed as

$$ET_L = ET_o \times K_L.$$  

The LIMP program calculates the regional daily mean $ET_o$ rates by month using the regional mean climate data from CIMIS, which are input into a table in the program. Then the regional climate data are copied to a second table in the program and are modified to represent the local microclimate. The daily mean $ET_o$ rates are again calculated for each month using the local microclimate data. The ratio of the local to the regional $ET_o$ rates is used as the microclimate correction factor. The program also has the capability to adjust $ET_o$ values for differences in slope and aspect of hills to determine the microclimate correction for undulating landscapes.

The vegetation $K_v$ coefficient provides an adjustment for the difference in ET between the vegetation of interest and the reference surface assuming that the vegetation is well-watered with a full canopy. The $K_v$ accounts for morphological and physiological differences between the vegetation and the reference surface ($ET_o$).

Sparse canopies have lower ET than dense canopies of the same vegetation and a density coefficient ($K_d$) is needed for the adjustment. The following correction for immature deciduous orchards is used to estimate $K_d$:

$$K_d = \sin \left( \frac{C_G \pi}{20} \right) \leq 1.0$$  

where $C_G$ is the percentage of ground covered by green growing vegetation.

\textsuperscript{1} University of California, Atmospheric Science, Davis, California  
\textsuperscript{2} California Department of Water Resources, Office of Water Use Efficiency, Sacramento, California
Many landscape species can experience water stress and still have a good appearance, so a landscape coefficient is used to adjust for reductions in $ET_L$ due to stress. For example, Bermuda grass can be stressed more than Fescue grass, so a stress coefficient can be used to differentiate the $ET_L$ of the two species. Monthly stress coefficient ($K_s$) values are input into the LIMP program to adjust for water or salinity stress. A coefficient of $K_s = 0$ would force $ET_L = 0$ and a $K_s = 1.0$ implies no reduction in $ET_L$ due to water stress. After entering the monthly data, daily $K_s$ values are computed for the entire year using a curve fitting technique.

The number-of-rainy-days per month (NRD) are input into the LIMP program, and it is used to estimate the rainfall frequency for each month. The rainfall frequency is used with $ET_o$ to estimate bare soil evaporation ($E_s$) using a 2-stage soil evaporation model. Then the bare-soil evaporation coefficient ($K_e$) is estimated as $E_s/ET_o$.

The LIMP program outputs all coefficients and $ET$ calculations for each day of the year. It also supplies information for irrigation scheduling in the worksheet RT. If the sprinkler system information is input, daily runtimes needed to replace the $ET_L$ losses and account for application efficiency are calculated. There are also features to help develop and optimize irrigation schedules. The LIMP program is available free of charge from the web site http://biomet.ucdavis.edu.
Vegetative Assessment in an Urban Environment

By Alan Walters, Agricast
Agricast is a small business, incorporated in the State of California, located at Escondido, CA. We are a satellite imagery distributor for Space Imaging and for Earthscan. Our principal product is image processing and not necessarily sale of raw, unprocessed imagery. We specialize in work where satellite imagery is used for land-use applications. Our address and contact information are shown below:

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Voice (760) 480-7884
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The work described here is a follow-on to research performed at the NASA Affiliated Research Center, San Diego State University, Department of Geography. It was during this research that image processing techniques necessary to measure irrigated vegetation were developed and refined.

This report describes the underlying research, the work performed for the City of Clovis and DWR, along with a description of how the work was performed and the processes used.
Research Work with the NASA Affiliated Research Center at SDSU

- NASA’s Objective -- build remote sensing and image processing capabilities in small companies.
  - SDSU ARC: Dept. Geography (Dr. Doug Stow and Dr. Alan Hope plus graduate staff).
  - Agricast invited to participate. Compensation was the experience gained while working with this world-class group of remote sensing scientists.
- Program Purpose -- To explore multiple techniques for mapping and quantifying urban landscape vegetation using 4m IKONOS satellite imagery as an alternative to more expensive 1m aerial imagery.
  - Results compared with a referenced map developed using 1m ADAR for accuracy assessment.
- Findings
  - Similar results obtained with IKONOS using simple to complex classification methods.
  - Unsupervised classification was best -- within 6% of reference.
  - NDVI Threshold surprisingly good and easy -- within 8% of reference.
  - Supervised classification least accurate -- within 12% of reference.
    - Principal problem -- shadow due to sun angle at time of year (9:30 AM, Jan 2000).
  - Separation of some classes (trees from shrubs, grass from ground cover) was not possible due to similar reflectance at NIR (near infra-red).

The IKONOS satellite (owned by Space Imaging) was launched in September 1999 and provides the first commercial source of high-resolution satellite imagery. Previous to IKONOS, work requiring high resolution imagery was accomplished using expensive digital aerial imagery at three and four times the price compared to this new satellite source. Since there were no examples of what could be accomplished with this new source of imagery, NASA sponsored a number of research projects through its Affiliated Research Centers (ARC), such as the Department of Geography at San Diego State University.

Agricast has a growing reputation of quality work in the area of land-use applications using satellite imagery and was invited to participate as the “visiting researcher”. Our compensation was the opportunity of refine existing image processing skills and learn new ones working under the supervision of a world class remote sensing faculty.

This project required six months of concentrated activity which included: field work, image processing, use of GIS, review and critique of results at SDSU, exploration of alternative methods at SDSU, and then back to the field for verification - validation.

Results of this program are shown on the slide with the principal finding that if one can be satisfied with an estimate of irrigated vegetation without knowing the proportion of trees and shrubs, to grass and ground cover -- a simple, quick NDVI slice is surprisingly accurate.
Ways to Classify a Scene

• **Unsupervised classification** -- uses an image processing algorithm in which multiple classes (100 in these cases) are selected for output. These classes are then visually identified, labeled and aggregated into landscaped vegetation or impervious classes. Requires good image interpretation skills. Process is time consuming.

• **Supervised classification** -- uses color coded example (training) areas identified within the scene to represent various feature classes. An image processing algorithm uses the spectral reflectance of each sample area to identify by color code all other similar reflectancies in the scene. Requires good image interpretation skills and meticulous selection of example areas. Can yield rapid results, but iteration often required until results agree with ground truth.

• **Normalized Difference Vegetation Index (NDVI)** is computed from the red and near-infrared (NIR) wavebands according to the following equation: \( \text{NDVI} = \frac{\text{NIR} - \text{red}}{\text{NIR} + \text{red}} \).
  - A threshold value is placed in the formula where pixels with values below the threshold are classified as impervious; values above the threshold are classified as landscaped vegetation.
  - The NDVI threshold value for the Del Mar area of 0.14 was determined through iterative visual assessment.
  - Requires good image interpretation skills but iteration process is quick and simple.

The classic way to classify features shown in satellite imagery is through either supervised or unsupervised classification. In an unsupervised classification, image processing software is used to separate reflectance in the scene into multiple classes -- 100 in the cases noted here. The next step is to visually identify each class, assigned a name, then consolidated with like classes by color. As an example, a highly reflective roofing material might spread across five or more classes. Each would be assigned the name “roof” and the same color.

Supervised classification uses example areas (training sets) to tell the image processing software what to look for. For example, a colored polygon would be used to identify “trees”; a second polygon of another color would be used to identify grass, and so-on until a training set has been established for each major feature in the scene. To limit the number of features, areas not germane to the analysis are often eliminated for the scene. From here the process is automated within the software, resulting in a color coded map showing each feature.

The Normalized Difference Vegetative Index is simply a comparison of the near infrared reflectance of healthy vegetation (band 4) with soil or other impervious surface (band 3). The result is shown in grayscale or can be color-coded. A threshold value may be entered into the NDVI formula to act as a cut-off, showing only values above the index. Quick, easy, and accurate.
The mechanical process of unsupervised process is shown here using Earth Resources Mapping image processing software. One must manually identify each class. This shows a scene divided into 18 classes. The writer normally commences at the bottom of the class index, turns the color automatically chosen by the software into a bright pink (different from everything else in the scene), and then visually identifies the feature. Once this is accomplished, the feature is named and assigned a color.

Please note that a feature can consist of more than one class due to different types of roofing materials, street paving, grass textures, tree densities, etc. One must keep the objective in mind when performing an unsupervised classification.

Here, the objective is the identification of irrigated vegetation by area. Imagine worn areas in a school yard or park. It would be perfectly accurate to classify these areas as dirt. But, dirt areas might not be included in the roll up of irrigated areas. This class might better be used to describe areas of raw earth. Consequently it would be better to classify these worn areas in play ground and parks as “grass” because these areas are irrigated along with the surrounding healthier areas.

Even so, there is no clear rule-of-thumb. It is the experience and image interpretation skills of the image processor that make the difference.
18 ClassesCollapsed to 6

This shows how multiple classes are collapsed to represent the different cover types. At the bottom, the bare dirt areas are color coded gray and identified as dirt. The streets and roof tops are color coded white and identified as impervious. Grass is color coded green, shrubs - light brown, trees dark green and red is used to identify brush.
As mentioned before, supervised classification uses example areas (training sets) to tell the image processing software what to look for. Shown here are example areas for impervious (streets and roofs) in white, barren areas in gray, brush in blue-gray, grass and ground cover in green, grass and dirt in yellow, trees and shrubs in dark green, agriculture (at the upper left center) in orange, and shadow in red.

From here the process is automated within the software. First calculate the statistics for the training areas and the run the classification algorithm. This results in the color coded map shown on the next slide.
And here is the result of the classification. One can look at the statistics and see an acreage count for the total scene (All), and acreage for each of the classified features in the scene.

However, note that while red was used to depict shadow as can been seen on the northwest sides of buildings at lower left of center, and along the northwest side of trees along streets, we have other red areas which are not shadow.

This is an example of confusion where water in the lagoons has the same dark spectral reflectance as dark areas in shadow. The result, misclassification. Subsequently, all areas not germane to the study were masked -- that is excluded from the scene -- leaving just the residential areas.

Then, we need not deal with the lagoons, the brush areas, and the barren areas under development. Masking allows focus on just what we were interested in: grass and groundcover, trees and shrubs, dirt and grass (to account for worn spots in play grounds and parks) combinations under irrigation, and other impervious surfaces such as roofs and streets.
Two areas were selected for detailed examination; the single family area at the left and an area of dense condominiums at the right. The object was to see if “rules of thumb” could be developed for application to other similar areas.

Additionally these areas were used as ground truth to measure the accuracy of the various classification methods used. This was accomplished by using ADAR multispectral 1m imagery to develop a land cover map. This map was verified and corrected through on the spot ground observation -- pixel by pixel. The result was used as “reference” for evaluation.
This is one of two ways to calculate areas covered by the various classes resulting from a classification from image processing routines; the other is to convert the raster data to vector and then import the resultant vector file into a Geographic Information System (GIS) such as ArcView (to be discussed later).

When image processing software is used to classify a scene, the routine will produce the statistics relative to each classification. Among the information produced, will be acreage for the entire scene and the area for each of the classified features, generated as a text file. Here the text file has been imported into Excel and edited to show just the area covered by each class.

For these areas in Del Mar, California, the single family area was 58 percent irrigated vegetation, largely in large median areas between a row of homes along the west side one street and the next row of homes along the east side of the next street to the west. Or visualized another way, the median area down the center of a city block between two rows of homes.

The condominium area amounted to 43 percent irrigated vegetation. The area was characterized by widely spaced two story condominiums with lush vegetation all around.
Shown here is an example of a more recently developed, very up-scale residential area in Del Mar. This is a composite where polygons representing grass and dirt, trees and shrubs, and grass and ground cover have been imported into ArcView. Yellow represents impervious surfaces such as streets, parking areas and roofs. Blue is grass and ground cover. Red is trees and shrubs. Area was calculated for each set of polygons and added together. This area amounted to 112.5 acres of which 34% was irrigated vegetation.

As to relative accuracy between the two methods, the writer’s opinion is statistics generated by the image processing software are more accurate. This is because generation of the vector polygons is sometimes incomplete, particularly when there are interior polygons among larger exterior ones.
Analysis of Reflectance

Spectral similarity between some species caused confusion and inaccuracy. Classes were collapsed to improve the overall accuracy of the classification.

These plots are called scattergrams and are used to evaluate training sites used for a supervised classification. The general rule of thumb is -- keep ellipsis representing the various classes as far apart as possible.

Our first attempt was to classify everything: impervious, chaparral, trees, shrubs, grass and dirt, grass, and then ground cover. The result was misclassification and the reason for the misclassification is shown at the upper left. Look along the vertical axis to see where the ellipsis which represent the spectral reflectance for each class at near infrared overlap one-another.

The solution is shown at the right where these classes were collapsed into more generalized classes of similar reflectance: blue green was used for chaparral, brownish green for tree-shrub, light green for grass and ground cover and yellow for dirt-grass.

This serves to make the point that as good as the sensors are on this new generation, high resolution satellite, there are still limitations. New, hyper-spectral sensors programmed for launch in the two years or so should provide the capability for more robust analysis and better discrimination between plant species.
When the limitations of multispectral analysis and classification techniques were noted, we then looked for a less time consuming process to achieve about the same result -- NDVI thresholding.

Normalized Difference Vegetative Index (NDVI) is a classic remote sensing algorithm used to measure healthy vegetation. Essentially this process works by measuring the reflectance of healthy vegetation in the near infrared portion of the infrared band and comparing this to a measurement of dirt or other non-reflective surfaces using the red band.

The formula used in the NDVI algorithm is \( \frac{NIR - Red}{NIR + Red} \). So if we write this as an if/then statement: 

\[
\text{if } \left( \frac{NIR-Red}{NIR+Red} \right) > 0.20 \text{ then input1 else null }
\]

every pixel less than .20 will be null (black) and those above .20 will be shown and accounted for in the statistics. The output is usually gray scale, but other color schemes may be used to show intensity above the threshold value like that above.

The process is quick and simple using Earth Resources Mapping software. Simply enter a cutoff value in the formula, click apply and immediately see the result. Change the cutoff value up or down, click apply and see that result.

Overall, results from the NDVI Slice technique turned out to be within 2% of the unsupervised classification. We concluded that results from unsupervised classification of a small area may be used to set a threshold which can then be applied over a much larger adjacent area. This will be discussed later.
A secondary finding of the work with SDSU was that 1m imagery was needed to precisely identify some features for classification and for verification -validation. Shown here is a comparison between 4m IKONOS multispectral imagery and the same area as depicted in 1m ADAR aerial imagery. There is no real comparison of cost between one and the other. IKONOS Reference 4m multispectral imagery at 25m horizontal accuracy (90%CE) will cost $29 per km2. ADAR will cost many times that depending upon the total area flown in the subscription. However, IKONOS offers 1m Panchromatic of the same area for an additional 50% or $43 per km2, so this is the number to be used when comparing to ADAR. The combination is called “pan sharpened” or “1m color”. Examples are shown on the following slide.

Consequently, we will normally propose the full (pan + multi-spectral) data set be used for analysis. If this becomes too costly, then we will look to obtain enough panchromatic to cover the areas identified for detailed analysis, which used to set the threshold for NDVI of the total area. The minimum buy is 100 km2 for either or both IKONOS 4m multispectral and/or 1m panchromatic imagery.
The California Department of Water Resources, San Joaquin District and the City of Clovis, California became interested in the project underway at San Diego State University and wished to see how well these techniques and data could be applied to areas in the San Joaquin Valley.

Once on contract, we immediately agreed the areas of interest and on the datum, projection and units of measure being used by Clovis and DWR GIS Departments. But the timing was such that had we ordered imagery at that point, the result would have been a winter scene. Instead it was agreed to place the imagery order for future acquisition in June or July 2001. Actual acquisition occurred on June 20th. The image data sets were processed and immediately delivered in .tif format for immediate use as base maps. At the same meeting all participants evaluated the scene and selected specific areas for detailed evaluation. The remainder of the project proceeded as summarized on the slide, and described on the following pages.
IKONOS imagery is delivered in 1-meter panchromatic format as shown on the left and/or 4-meter multi-spectral format as shown on the right. The multispectral format consists of four data sets: one for red, green, blue and near infra-red. Shown at upper right is the classic way an image processor will depict an infra-red scene using the near infra-red, red, and green bands. The result is called “false color”. Healthy vegetation is shown in tones of red with irrigated grass being the brightest. Areas of unirrigated grasslands are shown in green. Urban areas are shown in blue-gray, with some building roofs shown in light gray. The very dark areas are surface water ponds.
There are other ways to manipulate the bands in multi-spectral imagery. The scene at left is referred to as “natural color” and is accomplished using the red green and blue bands -- not the near infra-red band. At right is the false color scene described on the previous page.

However there is another difference. It is possible and quite easy to merge a panchromatic image of an area with the multi-spectral image of the same area. The result is 1-meter color.

Visually, the depiction is the same as 1m ADAR and is exceptionally useful when small features are to be identified for subsequent classification. But analysis is performed on the 4-meter multi-spectral data set alone and not the panchromatic.

So then it is fair to say that an ADAR derived classification is more accurate because of the discrimination of 1meter pixel versus what is possible using a 4-meter pixel. Work at SDSU showed this difference in accuracy to be about six percent. Then the question becomes one of whether the cost for six points of improved accuracy is worth the added expense?
Once we agree that accuracy of an satellite imagery derived analysis is not absolute; and that the best that might be expected is about six percent from reference, then the question becomes, is eight percent good enough for the application if this reduces processing cost?

Shown here is an initial application of the NDVI Slice technique to the Clovis area. It is easy to iterate the cut-off value. Simply high-light and change the number in the formula. At that point the “Apply changes” button activates. Click the button and immediately see the result. If it doesn’t look right then change the value and try again.
Does one value (such as .14 used at Del Mar) fit all types of vegetation and localities. Probably not due to differences in species and climates, even micro climates (or Evapotranspiration Zones).

After a number of iterations, .26 was chosen as a test reference for the time being and resulted in 22% of pixels in the scene being above the cut-off value.
The next step was to zoom into an area of interest slightly larger than one section or one square mile. Here the preliminary result was about 26% irrigated vegetation using .26 as the cutoff.

The remainder of the analysis was used to examine other areas in Clovis, CA using unsupervised and supervised classification and then use these results to refine the NDVI cutoff value.
The first step was to perform the unsupervised classification and then use these results as training areas for the supervised classification. The color convention used in both:

- gray: impervious (roofs, streets)
- lt. brown: bare ground
- lt. green: grass & ground cover
- dk. green: trees and shrubs
- lt. blue: surface water
- purple: swimming pools
- red: shadow

Almost immediately it was noted that there was very little shadow in the scene compared to the Del Mar imagery. This is due to sun elevation at time of year. June acquisition for the Clovis imagery; January acquisition for Del Mar. Additionally the overall results for the unsupervised classification and the supervised classification are almost the same due to the absence of shadow.
With the classified results known and verified, the NDVI threshold was revisited, reduced to .20, and then the statistics were recalculated. This resulted in 2983 pixels in the scene being above cut-off or 28 percent; strong correlation with the classified results.

Sub scenes from the unsupervised, supervised and NDVI classifications were then calculated and compared. These are shown on the following slides.
The unsupervised classification is shown at left with the supervised classification shown at right. The first thing that is noticeable between the two is the light blue areas depicting surface water.

The problem with this class was that surface water is as dark a reflectance as some of the asphalt sections of street paving. This was simply a judgement call of which was most important to show -- the paving areas without misclassification or the full extent of the surface water.

Surface water had a very different reflectance compared to swimming pools due to the concrete bottoms which made swimming pools reflect light differently. Pools are shown in purple. The pool at upper right center is an very large pool at a school.

Overall the irrigated vegetation results of the two classifications are very similar:

Unsupervised 33%
Supervised 36%
This is the NDVI classification of the same area showing 32% irrigated vegetation. The comparison between this calculation and the classifications is shown on the slide.
This is a 1-meter false color scene. This area is largely single family residential with the exception of a small condominium area at the upper left. Time of development is older to the left, newer and slightly more up-scale to the right. Two areas of ornamental pools were detected at lower right of center.
Total irrigated vegetation in this area -- 30.3%. Better classification was achieved for the ornamental ponds here in the unsupervised case than using the supervised routine as shown on the next slide.
This is the supervised classification of the same area. Total irrigated vegetation using the supervised classification procedures is 35.6%.
This is the NDVI classification at 31% irrigated vegetation with falls into line with the Unsupervised classification.
This is a zoom into the condominium area shown at the upper left of the previous scene. This is a very small area measuring slightly more than 14 acres. Notice the four swimming pools shown in the scene.
Thus is the supervised classification at top and the unsupervised classification shown at bottom. Calculations between the two are similar. However notice the swimming pools. There are differences in the number of pixels calculated as pools in the two classifications. From left to right:

Pool 1  Supervised 2  Unsupervised 2
Pool 2  Supervised 4  Unsupervised 2
Pool 3  Supervised 2  Unsupervised 2
Pool 4  Supervised 3  Unsupervised 2

Eleven pixels in the supervised classification compared to eight pixels in the unsupervised classifications accounts for the differences in the calculation for swimming pool area.

We were also able to account for some shadow in the unsupervised classification as shown in red -- too small an amount to attempt in the supervised classification for fear of misclassification of the adjacent trees.
This is the NDVI classification for the Condominium area with the comparison between this method and the classifications shown on the slide. The results from the NDVI classification compare favorably with the unsupervised classification.
This is a single-family residential area slightly up-scale from those previously shown and very similar to the newly developed upscale area in Del Mar where the percentage of irrigated vegetation was 34 percent.
AOI-3 Unsupervised Classification

- Total Area = 165 acres
- Tree_shrub = 16.5 ac.
- Grass_gcvr = 41.6 ac.
- Pool = 1.4 acres

Total Irrigation Vegetation 35.2%

This is the unsupervised classification showing about 1.4 acres in swimming pools and an overall 35 percent of irrigated vegetation.
AOI-3 Supervised Classification

- Total Area -- 165 acres
- Tree/shrub -- 17.5 ac.
- Grass/gcvr -- 47.3 ac.
- Pool -- 1.7 acres

Total Irrigation Vegetation 39.3%

Compared to the supervised classification showing 1.7 acres in swimming pools and an overall 39 percent in irrigated vegetation.
The NDVI classification falls between the previous classifications but, as in past cases, and as in Del Mar, tends to favor the unsupervised classification. The comparison between methods is shown on the slide.
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THE BROWN ACT

OPEN MEETINGS FOR LOCAL LEGISLATIVE BODIES

2003

CALIFORNIA ATTORNEY GENERAL’S OFFICE
THE
BROWN
ACT

OPEN MEETINGS FOR
LOCAL LEGISLATIVE BODIES

Office of the Attorney General
Bill Lockyer
Attorney General

Prepared by the Division of Civil Law

Chief Assistant Attorney General Andrea Lynn Hoch
Deputy Attorney General Ted Prim, Editor
Throughout California’s history, local legislative bodies have played a vital role in bringing participatory democracy to the citizens of the state. Local legislative bodies - such as boards, councils and commissions - are created in recognition of the fact that several minds are better than one, and that through debate and discussion, the best ideas will emerge. The law which guarantees the public’s right to attend and participate in meetings of local legislative bodies is the Ralph M. Brown Act.

While local legislative bodies generally are required to hold meetings in open forum, the Brown Act recognizes the need, under limited circumstances, for these bodies to meet in private in order to carry out their responsibilities in the best interests of the public. For example, the law contains a personnel exception based on notions of personal privacy, and a pending litigation exception based upon the precept that government agencies should not be disadvantaged in planning litigation strategy. Although the principle of open meetings initially seems simple, application of the law to real life situations can prove to be quite complex.

The purpose of this pamphlet is to provide a brief description of the Brown Act, along with a discussion of court decisions and opinions of this office that add to our understanding by applying it in specific factual contexts. We hope this pamphlet will assist both public officials and those who monitor the performance of local legislative bodies to minimize and resolve disputes over interpretations of the Brown Act. In recent years, both the California Supreme Court and the courts of appeal have recognized the benefit of pamphlets issued by our office. This recognition by the courts, along with many favorable comments from members of the public, strengthens our resolve to continue producing reliable informational materials on the Brown Act and other California laws. Publication of these materials constitutes a tradition of service that we value greatly.

Ideas and suggestions for future editions of this pamphlet are welcomed and should be addressed to the editor.

Sincerely,

BILL LOCKYER
Attorney General

1300 I Street • Suite 1740 • Sacramento, California • 95814
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INTRODUCTION

This pamphlet concerns the provisions of the Ralph M. Brown Act, which govern open meetings for local government bodies. The Brown Act is contained in section 54950 et seq. of the Government Code. Accordingly, all statutory references in this pamphlet are to the Government Code unless otherwise noted. The pamphlet contains a table of contents, which may also serve as a topical outline for the reader. The pamphlet also includes a brief summary of the main provisions of the Brown Act, along with references to the appropriate Government Code sections and chapters of the text. The text includes a discussion of the law along with tips on how the law should be applied in particular situations. Numerous references are made to legal authorities throughout the text. A copy of the Brown Act in its entirety is set forth in the appendix to the pamphlet. Lastly, the pamphlet contains a table of authorities so that the reader can determine all of the places in the text where references are made to a particular authority.

In preparing this pamphlet, we relied on a variety of legal resources. Appellate court cases were consulted and are cited throughout the pamphlet. While most of the more significant cases are discussed, this pamphlet is not intended to be a compendium of all court cases in this area. In addition, we drew upon published opinions and unpublished letter opinions issued by this office. Attorney General opinions, unlike appellate court decisions, are advisory only and do not constitute the law of the state. However, with respect to the Brown Act, the courts have frequently adopted the analysis of Attorney General opinions, and have commented favorably on the service afforded by those opinions and this pamphlet. (Bell v. Vista Unified School Dist. (2000) 82 Cal.App.4th 672; Freedom Newspapers v. Orange County Employees Retirement System (1993) 6 Cal. 4th 821, 829.)

Published opinions are cited by volume and page number (e.g., 32 Ops.Cal.Atty.Gen. 240 (1958)). Unpublished letter opinions are cited as indexed letters by year and page number (e.g., Cal.Atty.Gen., Indexed Letter, No. IL 76-201 (October 20, 1976).) Published opinions are available through law libraries and some attorneys’ offices. As a general rule, indexed letters are available only in the Office of the Attorney General. Copies may be obtained by a request to the Public Inquiry Unit of the Office of the Attorney General.

If you have specific questions or problems, the statutes, cases and opinions should be consulted. You also may wish to refer the matter to the attorney for the agency in question, a private attorney or the district attorney.

The pamphlet is current through January 2003 with respect to statutes, case law, and Attorney General opinions.
SUMMARY OF KEY BROWN ACT PROVISIONS

COVERAGE

PREAMBLE:

Public commissions, boards, councils and other legislative bodies of local government agencies exist to aid in the conduct of the people’s business. The people do not yield their sovereignty to the bodies that serve them. The people insist on remaining informed to retain control over the legislative bodies they have created.

GOVERNING BODIES:

Includes city councils, boards of supervisors, and district boards. Also covered are other legislative bodies of local government agencies created by state or federal law.

SUBSIDIARY BODIES:

Includes boards or commissions of a local government agency as well as standing committees of a legislative body. A standing committee has continuing subject matter jurisdiction or a meeting schedule set by its parent body. Less-than-a-quorum advisory committees, other than standing committees, are exempt.

PRIVATE OR NONPROFIT CORPORATIONS OR ENTITIES:

Covered only if:

a. A legislative body delegates some of its functions to a private corporation or entity; or

b. If a legislative body provides some funding to a private corporation or entity and appoints one of its members to serve as a voting member of entity’s board of directors.
MEETING DEFINED

INCLUDES:

Any gathering of a quorum of a legislative body to discuss or transact business under the body’s jurisdiction; serial meetings are prohibited.

EXEMPTS:

(1) Individual contacts between board members and others which do not constitute serial meetings;

(2) Attendance at conferences and other gatherings which are open to public so long as members of legislative bodies do not discuss among themselves business of a specific nature under the body’s jurisdiction;

(3) Attendance at social or ceremonial events where no business of the body is discussed.

LOCATIONS OF MEETINGS:

A body must conduct its meetings within the boundaries of its jurisdiction unless it qualifies for a specific exemption.

TELECONFERENCE MEETINGS:

Teleconference meetings may be held under carefully defined conditions. The meeting notice must specifically identify all teleconference locations, and each such location must be fully accessible to members of the public.

PUBLIC RIGHTS

PUBLIC TESTIMONY:

Public may comment on agenda items before or during consideration by legislative body. Time must be set aside for public to comment on any other matters under the body’s jurisdiction.
NON-DISCRIMINATORY FACILITIES:
Meetings may not be conducted in a facility that excludes persons on the basis of their race, religion, color, national origin, ancestry, or sex, or that is inaccessible to disabled persons, or where members of the public may not be present without making a payment or purchase.

COPY OF RECORDING:
Public may obtain a copy, at cost, of an existing tape recording made by the legislative body of its public sessions, and to listen to or view the body’s original tape on a tape recorder or viewing device provided by the agency.

PUBLIC VOTE:
All votes, except for those cast in permissible closed session, must be cast in public. No secret ballots, whether preliminary or final, are permitted.

CLOSED MEETING ACTIONS/DOCUMENTS:
At an open session following a closed session, the body must report on final action taken in closed session under specified circumstances. Where final action is taken with respect to contracts, settlement agreements and other specified records, the public may receive copies of such records upon request.

TAPING OR BROADCASTING:
Meetings may be broadcast, audio-recorded or video-recorded so long as the activity does not constitute a disruption of the proceeding.

CONDITIONS TO ATTENDANCE:
Public may not be asked to register or identify themselves or to pay fees in order to attend public meetings.

PUBLIC RECORDS:
Materials provided to a majority of a body which are not exempt from disclosure under the Public Records Act must be provided, upon request, to members of the public without delay.
REQUIRED NOTICES AND AGENDAS

REGULAR MEETINGS:
Agenda containing brief general description (approximately twenty words in length) of each matter to be considered or discussed must be posted at least 72 hours prior to meeting.

SPECIAL MEETINGS:
Twenty-four hour notice must be provided to members of legislative body and media outlets including brief general description of matters to be considered or discussed.

EMERGENCY MEETINGS:
One hour notice in case of work stoppage or crippling activity, except in the case of a dire emergency.

CLOSED SESSION AGENDAS:
All items to be considered in closed session must be described in the notice or agenda for the meeting. A model format for closed-session agendas appears in section 54954.5. Prior to each closed session, the body must orally announce the subject matter of the closed session. If final action is taken in closed session, the body generally must report the action at the conclusion of the closed session.

AGENDA EXCEPTION:
Special procedures permit a body to proceed without an agenda in the case of emergency circumstances, or where a need for immediate action came to the attention of the body after posting of the agenda.
CLOSED-SESSION MEETINGS

PERSONNEL EXEMPTION:
The body may conduct a closed session to consider appointment, employment, evaluation of performance, discipline or dismissal of an employee. With respect to complaints or charges against an employee brought by another person or another employee, the employee must be notified, at least 24 hours in advance, of his or her right to have the hearing conducted in public.

PUBLIC SECURITY:
A body may meet with law enforcement or security personnel concerning the security of public buildings and services.

PENDING LITIGATION:
A body may meet in closed session to receive advice from its legal counsel concerning existing litigation, initiating litigation, or situations involving a significant exposure to litigation. The circumstances which constitute significant exposure to litigation are expressly defined in section 54956.9(b)(3).

LABOR NEGOTIATIONS:
A body may meet in closed session with its negotiator to consider labor negotiations with represented and unrepresented employees. Issues related to budgets and available funds may be considered in closed session, although final decisions concerning salaries of unrepresented employees must be made in public.

REAL PROPERTY NEGOTIATIONS:
A body may meet in closed session with its negotiator to consider price and terms of payment in connection with the purchase, sale, exchange or lease of real property.

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REMEDIES AND SANCTIONS

CIVIL REMEDIES:

Individuals or the district attorney may file civil lawsuits for injunctive, mandatory or declaratory relief, or to void action taken in violation of the Act.

Attorneys’ fees are available to prevailing plaintiffs.

CRIMINAL SANCTIONS:

The district attorney may seek misdemeanor penalties against a member of a body who attends a meeting where action is taken in violation of the Act, and where the member intended to deprive the public of information which the member knew or has reason to know the public was entitled to receive.
CHAPTER I.

PURPOSE AND SCOPE

The Ralph M. Brown Act (Gov. Code, § 54950\(^1\) et seq., hereinafter “the Brown Act,” or “the Act”) governs meetings conducted by local legislative bodies, such as boards of supervisors, city councils and school boards. The Act represents the Legislature’s determination of how the balance should be struck between public access to meetings of multi-member public bodies on the one hand and the need for confidential candor, debate, and information gathering on the other. As the rest of this pamphlet will indicate, the Legislature has established a presumption in favor of public access. As the courts have stated, the purpose of the Brown Act is to facilitate public participation in local government decisions and to curb misuse of the democratic process by secret legislation by public bodies. (*Cohan v. City of Thousand Oaks* (1994) 30 Cal.App.4th 547, 555.) To these ends, the Brown Act imposes an “open meeting” requirement on local legislative bodies. (§ 54953 (a); *Boyle v. City of Redondo Beach* (1999) 70 Cal.App.4th 1109, 1116.)

However, the Act also contains specific exceptions from the open meeting requirements where government has a demonstrated need for confidentiality. These exceptions have been construed narrowly; thus if a specific statutory exception authorizing a closed session cannot be found, the matter must be conducted in public regardless of its sensitivity. (§ 54962; *Rowen v. Santa Clara Unified School District* (1981) 121 Cal.App.3d 231, 234; 68 Ops.Cal.Atty.Gen. 34, 41-42 (1985).)

Where matters are not subject to a closed meeting exception, the Act has been interpreted to mean that all of the deliberative processes by legislative bodies, including discussion, debate and the acquisition of information, be open and available for public scrutiny. (*Sacramento Newspaper Guild v. Sacramento County Bd. of Suprs.* (1968) 263 Cal.App.2d 41; 42 Ops.Cal.Atty.Gen. 61, 63 (1963); 32 Ops.Cal.Atty.Gen. 240 (1958).) The Act only applies to multi-member bodies such as councils, boards, commissions and committees since, unlike individual decision makers, such bodies are created for the purpose of reaching collaborative decisions through public discussion and debate.

A host of provisions combine to provide public access to the meetings of legislative bodies. For example, the times and dates of all meetings must be noticed and an agenda must be prepared providing a brief general description of all matters to be discussed or considered at the meeting. (§§ 54954, 54954.2.) As a precondition to attending the meeting, members of the public may not be asked to provide their names. (§ 54953.3.) While in attendance, members of the public may make video or audio recordings of the meeting. (§ 54953.5.) As a general rule, information given to a majority of the members of the legislative body in connection with an open meeting must be equally available to members of the public. (§ 54957.5.) Before or during consideration of each agenda item, the public must be given an opportunity to comment on the item. (§ 54954.3(a).)

\(^1\) All statutory references are to the Government Code except as otherwise indicated.
While the Act creates broad public access rights to the meetings of legislative bodies, it also recognizes
the legitimate needs of government to conduct some of its meetings outside of the public eye. Closed-
session meetings are specifically defined and are limited in scope. They primarily involve personnel
issues, pending litigation, labor negotiations and real property acquisitions. (§§ 54956.8, 54956.9,
54957, 54957.6.) Each closed-session meeting must be preceded by a public agenda and by an oral
announcement. (§§ 54954.2, 54957.7.) When final action is taken in closed session, the legislative
body may be required to report on such action. (§ 54957.1.)

The following chapters contain a more detailed discussion of the persons governed by the Act, the
notice and agenda requirements, access rights of the public, limitations on closed sessions and
available remedies for violation of the Act.

CHAPTER II.

BODIES SUBJECT TO THE BROWN ACT

The Brown Act applies to the “legislative bodies” of all local agencies in California, e.g., councils,
boards, commissions and committees. (§§ 54951, 54952.) In addition, any person elected to serve as
a member of a legislative body who has not assumed the duties of office shall conform his or her
conduct to the requirements of the Act, and shall be treated for purposes of enforcement of the Act as
if he or she had already assumed office. (§ 54952.1; see, 216 Sutter Bay Associates v. County of Sutter

The Act does not apply to individual decision makers who are not elected or appointed members of
legislative bodies such as agency or department heads when they meet with advisors, staff, colleagues
or anyone else. Similarly, the Act does not apply to multi-member bodies which are created by an
(1973).) However, where a body directs or authorizes a single individual to appoint a body, it would
probably be subject to the Act. (Frazer v. Dixon Unified School District (1993) 18 Cal.App.4th 781,
793; International Longshoremen’s & Warehousemen’s Union v. Los Angeles Expert Terminal, Inc.
(1999) 69 Cal.App.4th 287, 297.) Boards and commissions that are created by statute or ordinance
are subject to the Act even if they are under the jurisdiction of an individual department head.

A single individual acting on behalf of an agency is not a “legislative body” since the definition of that
term connotes a group of individuals. Thus, a hearing officer, functioning by himself or herself in an
employee disciplinary hearing, is not a legislative body (Wilson v. San Francisco Mun. Ry. (1973) 29
Cal.App.3d 870, 878-879), nor is an individual city councilmember screening candidates for a vacant
city office. (Cal.Atty.Gen., Indexed Letter, No. IL 76-181 (September 13, 1976).)
The Act applies to the meetings of “legislative bodies” of “local agencies.” An understanding of each of these terms is necessary in order to properly apply the provisions of the Act to individual situations. These terms will be discussed in the following sections.

1. **Local Agencies**

Local agencies include all cities, counties, school districts, municipal corporations, special districts, and all other local public entities. (§ 54951.) The first determination one must make in assessing the applicability of the Act is whether the agency is local in nature. If the agency is essentially local in character, it is probably subject to the Act. (§ 54951.) If, however, the agency is a multi-member state body, the Bagley-Keene Act applies. (§ 11120 et seq.) The fact that an agency is created by state or federal law, rather than local ordinance, does not mean that the agency is not essentially local in character. (§ 54952(a).) Factors in assessing the local versus state character of a body may include: the geographical coverage of the agency, the duties of the agency, provisions concerning membership and appointment, or the existence of an oversight agency.

The issue of whether an agency is local or state in character was addressed in *Torres v. Board of Commissioners* (1979) 89 Cal.App.3d 545, in the context of determining whether a housing authority was subject to the Act. The court stated:

“While a housing authority may be a state agency for some purposes . . . if it is within the Brown Act’s definition of a local agency, it is simply not included within the State Act. We hold that a housing authority created by Health and Safety Code section 34200 et seq. is included within the statutory definition of a local agency under the Brown Act in that it is either an ‘other local public agency’ or a ‘municipal corporation’ or both, as those terms are used in Government Code section 54951. . . . The term ‘municipal corporation’ is broader than the term ‘city,’ particularly when the term ‘city’ already appears in the applicable statute. . . . In order to give meaning to the term ‘municipal corporation’ in Government Code section 54951 we hold that such term is not restricted to its technical sense of a ‘city,’ general law or charter, but rather includes such entities as housing authorities. . . . In addition, a housing authority is local in scope and character, restricted geographically in its area of operation, and does not have statewide power or jurisdiction even though it is created by, and is an agent of, the state rather than of the city or county in which it functions. . . .

“Furthermore, as perceptively noted by the trial court, the placement of Government Code section 11120 and its history is some persuasive indication that the State Act was meant to cover executive departments of the state government and was not meant to cover local agencies merely because they were created by state law. A housing authority is no more a state agency under
these acts than is a city or a county. The fact that such entities from time to
time administer matters of state concern may make them state agents for such
purposes but not state agencies under the open meeting acts.” [Citations
omitted.] (Torres v. Board of Commissioners (1979) 89 Cal.App.3d 545, 549-
550.)

The Act has also been found to apply to an air pollution control district (71 Ops.Cal.Atty.Gen.
96 (1988)), a regional open space district (73 Ops.Cal.Atty.Gen. 1 (1990), and to such other
local bodies as area and local voluntary health planning agencies (Cal.Atty.Gen., Indexed
Letter, No. IL 72-79 (April 4, 1979).) The Act is a matter of statewide concern and, therefore,
applies equally to charter and general law cities. (San Diego Union v. City Council (1983) 146
Cal.App.3d 947, 957.)

The Act does not apply to the judicial branch of government or boards and commissions which
are an adjunct to the judiciary. (See Cal.Atty.Gen., Indexed Letter, No. IL 75-109 (June 3,
Letter, No. IL 60-16 (February 14, 1960).) This office has also concluded the Act is not
applicable to county central committees of a political party because they are neither public
entities nor are they included in any of the special statutory provisions of the Act. (59

2. Legislative Bodies

Having concluded that the Act applies to bodies that are “local" in character, we turn now to
a discussion of the requirement that such local bodies qualify as “legislative bodies” within the
meaning of the Act. The term “legislative body” is not used in its technical sense in the Act.
(§ 54952.) The Act’s application is not limited to boards and commissions insofar as they
perform “legislative” functions. Bodies that perform actions which are primarily executive or
quasi-judicial in nature are also subject to the Act as well. (61 Ops.Cal.Atty.Gen. 220 (1978);

In the past, the different types of bodies covered by the Act were set forth in several
Government Code sections. This approach led to confusion with respect to the
interrelationship between these sections and exemptions contained within them. (Freedom
Newspapers v. Orange County Employees Retirement System (1993) 6 Cal.4th 821.) In 1994,
the Legislature amended the Act to consolidate, into a single section, all of the provisions
defining those bodies that are subject to the Act’s requirements. (§ 54952.) By so doing, the
Legislature hoped to clarify the definitions and the exemptions contained in them.

Below is a discussion of the various types of bodies that are defined as “legislative bodies” for
purposes of the Act.
A. Governing Bodies

The governing bodies of local government agencies are the most basic type of body subject to the Act’s requirements. These include the board of supervisors of a county, the city council of a city or the governing board of a district. (§ 54952(a).) In addition, the Act expressly applies to local bodies created by state or federal statute. (§ 54952(a).) The board of directors for a joint powers authority would be covered as a governing body of a local agency; joint powers authorities are also covered because they are created according to a procedure established by state law. (§ 6500 et seq.)

B. Subsidiary Bodies

Any board, commission, committee or other body of a local agency created by charter, ordinance, resolution or formal action of a legislative body is itself a legislative body. (§ 54952(b).) Generally, this is the case regardless of whether the body is permanent or temporary, advisory or decisionmaking. However, there is a specific exemption for an advisory committee which is comprised solely of less than a quorum of the members of the legislative body that created the advisory body. (§ 54952(b).) This exception does not apply if the advisory committee is a standing committee. (§ 54952(b).) A standing committee is a committee which has continuing jurisdiction over a particular subject matter (e.g., budget, finance, legislation) or if the committee’s meeting schedule is fixed by charter, ordinance, resolution or other formal action of the legislative body that created it. (See examples, infra, p. 6.)

The term “formal action” is used twice in section 54952(b) in connection with advisory committees and standing committees. The term “formal action of a legislative body” appears to be a term intended to distinguish between the official actions of the body and the informal actions of particular board members. For example, in Joiner v. City of Sebastopol (1981) 125 Cal.App.3d 799, 805, the court concluded that the city council had taken formal action by designating two of its members to sit on an advisory committee and establish the committee’s agenda, even though the council did not act by formal resolution. Similarly, in Frazer v. Dixon Unified School District (1993) 18 Cal.App.4th 781, 792-793, the court indicated that a school board’s authorization to the superintendent to appoint a committee under specified circumstances constituted a creation of an advisory committee by formal action of the board. “Formal action of a legislative body” is not limited to a formal resolution or a formal vote by the body.

When a legislative body designates less than a quorum of its members that does not constitute a standing committee to meet with representatives of another legislative body to exchange information and report back to their respective bodies, a meeting between the representatives would be exempt from the Act. (Joiner v. City of Sebastopol (1981) 125 Cal.App.3d 799, 805.) However, if a legislative body designates less than a quorum of its members to meet with representatives of another legislative body to
perform a task, such as the making of a recommendation, an advisory committee consisting of the representatives from both bodies would be created. Such a committee would be subject to the open meeting and notice provisions of the Act. (Joiner v. City of Sebastopol (1981) 125 Cal.App.3d 799, 805.) The fact that the advisory committee was contingent upon the second body’s compliance does not detract from the conclusion that the creation of the committee must be attributed to the first body’s action. (Joiner v. City of Sebastopol (1981) 125 Cal.App.3d 799, 805.)

The following illustrates how section 54952(b) operates. A city council creates four bodies to address various city problems.

- Commission comprised of councilmembers, the city manager and interested citizens: This committee is covered by the Act because there is no exemption for it regardless of whether it is decisionmaking or advisory in nature.

- Advisory committee comprised of two councilmembers for the purpose of reviewing all issues related to parks and recreation in the city on an ongoing basis: This committee is a standing committee which is subject to the Act’s requirements because it has continuing jurisdiction over issues related to parks and recreation in the city.

- Advisory committee comprised of two city councilmembers for the purpose of producing a report in six months on downtown traffic congestion: This committee is exempt advisory committee because it is comprised solely of less than a quorum of the members of the city council. It is not a standing committee because it is charged with accomplishing a specific task in a short period of time, i.e., it is a limited term ad hoc committee.

- Advisory committee comprised of two councilmembers to meet on the second Monday of each month pursuant to city council resolution: This committee is subject to the Act as a standing committee because its meeting schedule is fixed by the city council.

C. Private or Nonprofit Corporations and Other Entities

Under specified circumstances, meetings of boards, commissions, committees or other multi-member bodies that govern private corporations, limited liability companies or other entities may become subject to the open meeting requirements of the Act. Ordinarily, these private corporations or other entities will be nonprofit corporations. In some instances, they are created by the governmental entity to support the efforts of the governmental entity. Other times they are privately created and, to some degree, may partner with a governmental entity to accomplish a common goal. (See Ed. Code, § 47604(a) [concerning possible application to charter schools].) The circumstances
that determine whether nonprofit corporations or other entities are governed by the Brown Act are set forth in section 54952(c).

The Act expressly applies to private corporations, limited liability companies and other entities that are created by the legislative body for the purpose of exercising authority which can be lawfully delegated to them. (§ 54952(c)(1); Epstein v. Hollywood Entertainment District II Business Improvement District (2000) 85 Cal.App.4th 152 [Property Owners Association covered because it received money from taxes on property and businesses within the Business Improvement District, and it was structured to assume certain administrative functions ordinarily performed by the city]; 85 Ops.Cal.Atty.Gen. 55 (2002) [Act covered private nonprofit corporation formed for the purpose of providing programming for a cable television channel set aside for educational use by a cable operator pursuant to its franchise agreement with a city and subsequently designated by the city to provide the programming services]; 81 Ops.Cal.Atty.Gen. 281, 290 (1998) [community redevelopment agency created nonprofit entity and delegated authority to it].) Typically, the entities subject to this subdivision will be nonprofit corporations established jointly by various government entities for the purpose of constructing, operating or maintaining a public works project or public facility. (International Longshoremen’s & Warehousemen’s Union v. Los Angeles Expert Terminal, Inc. (1999) 69 Cal.App.4th 287, 294.)

The Act also applies to the meetings of entities which receive funds from a local agency where the legislative body for the local agency appoints one of its members to the governing board of the entity as a voting member of the board. (§ 54952(c)(2).) The Act does not apply to boards of a nonprofit corporation or other entity where the legislative body appoints someone other than one of its own members to the governing body of such entity. It continues to be the law that the mere receipt of public funds by a nonprofit corporation or other entity does not subject it to the requirements of the Act.

D. Hospital Lessees

The Act expressly applies to the meetings of lessees of hospitals pursuant to Health and Safety Code section 32121, subdivision (p), where the hospital or any part of it was first leased after January 1, 1994, where the lessee exercises any delegated authority of a local government agency, whether or not the lessee was organized and operated by the local government agency or a delegated authority. (§ 54952(d).)
CHAPTER III.
MEETING DEFINED

The term “meeting” is defined in section 54952.2 and expressly discusses several types of meeting formats. First, the term “meeting” includes any congregation of a majority of the members of a legislative body at the same time and place to hear, discuss or deliberate upon any matter which is under the subject matter jurisdiction of the agency. (§ 54952.2(a).) Under this definition, face to face gatherings of a legislative body in which issues under the subject matter jurisdiction of the body are discussed, decided or voted upon are meetings subject to the Brown Act. Informal gatherings such as lunches or social gatherings also would constitute meetings if issues under the subject matter jurisdiction of the body are discussed or decided by the member of the body. Second, the Act specifically prohibits any use of direct communication, personal intermediaries or technological devices that is employed by a majority of the members of the legislative body to develop a collective concurrence as to action to be taken. (§ 54952.2(b).) Most often this type of meeting is conducted through a series of communications by individual members or less-than-a-quorum groups, ultimately involving a majority of the body’s members. These meetings are called serial meetings. The Act also expressly excludes specified gatherings from its definition of a meeting. (§ 54952.2(c).)

Specific issues relating to these meeting formats are discussed below.

1. **Face to Face Meetings**

The definition of the term “meeting” contained in section 54952.2(a) includes any congregation of a majority of the members of a body at the same time and place to hear, discuss or deliberate on any issue under the subject matter jurisdiction of the body. This definition makes it clear that the body need not take any action in order for a gathering to be defined as a meeting. A gathering is a meeting if a majority of the members of the body merely receive information or discuss their views on an issue. A meeting also covers a body’s deliberations, including the consideration, analysis or debate of an issue, and any vote which may ultimately be taken. Under this construction, any gathering of a majority of the members of a body to receive information, hear a proposal, discuss an issue or take any action on an issue under the subject matter jurisdiction of the body is a meeting subject to the notice and open meeting requirements of the Act.

Under section 54952.2, as well as prior case law, a gathering need not be formally convened in order to be covered by the Act. In *Sacramento Newspaper Guild v. Sacramento County Bd. of Suprs.* (1968) 263 Cal.App.2d 41, the court held that a luncheon gathering which included five county supervisors, the county counsel, a variety of county officers, and representatives of a union to discuss a strike which was under way against the county was a meeting within
the meaning of the Act. Therefore, the meeting should have been noticed and members of the media and public should have been admitted to witness the meeting. In reaching its conclusion, the court stated:

“An informal conference or caucus permits crystallization of secret decisions to a point just short of ceremonial acceptance. There is rarely any purpose to a nonpublic pre-meeting conference except to conduct some part of the decisional process behind closed doors. Only by embracing the collective inquiry and discussion stages, as well as the ultimate step of official action, can an open meeting regulation frustrate these evasive devices. As operative criteria, formality and informality are alien to the law’s design, exposing it to the very evasions it was designed to prevent. Construed in the light of the Brown Act’s objectives, the term ‘meeting’ extends to informal sessions or conferences of the board members designed for the discussion of public business. The Elks Club luncheon, attended by the Sacramento County Board of Supervisors, was such a meeting.” (Sacramento Newspaper Guild v. Sacramento County Bd. of Suprs. (1968) 263 Cal.App.2d 41, 50-51; see also 42 Ops.Cal.Atty.Gen. 61 (1963) [“informal,” “study,” “discussion,” “informational,” “factfinding,” or “precouncil” gatherings of a quorum of the members of a board are within the scope of the Act as meetings].)

The Act contains the following specific exemptions.

A. Conferences and Retreats

The Act exempts conferences and similar gatherings, which are open to the public, that involve issues of interest to the public or to public agencies of the type represented by the legislative body in question, so long as the majority of the members of the legislative body do not discuss among themselves, other than as part of the scheduled program, any issues of a specific nature which are within the subject matter jurisdiction of the legislative body. (§ 54952.2(c)(2).) However, the conference need not necessarily be a conference of public agencies to fall within the exemption; rather, the gathering could be a conference of media outlets, environmental organizations, health care entities, social welfare organizations so long as the subject of the conference is related to the body’s jurisdiction. The exemption for conferences does contain two limitations. First, a majority of the members of the legislative body in attendance at the conference may not caucus or discuss among themselves business of a specific nature within the body’s jurisdiction. However, members may enter into discussions on issues or business affecting their local agency in a public forum as part of the scheduled program of the conference. Second, the conference must be open to the public, although the exemption specifically provides that a member of the public need not be provided with free admission where others are charged a fee.
Agency retreats, unlike conferences, do not involve a number of public agencies and interested individuals apart from the legislative body itself. Therefore, retreats continue to be subject to the open meeting and notice requirements of the Act.

B. Other Public Meetings

When a majority of a legislative body attends an open and publicized meeting held by a person or organization, other than the local agency on a matter of local interest, the legislative body is not deemed to be conducting a meeting, so long as the members in attendance do not discuss among themselves, other than as part of the scheduled program, issues of a specific nature related to the subject matter jurisdiction of the body. (§ 54952.2(c)(3).) This exception applies to attendance at a meeting conducted by a private individual, or private organization, so long as the meeting concerns issues of local interest and is open to the public and well publicized in advance. Under the terms of the exception, members of a legislative body who attend a meeting conducted by another person or organization may not caucus or discuss among themselves specific business within the body’s jurisdiction. However, a member of the legislative body may discuss issues related to the purpose of the meeting during public testimony. Candidate debates including incumbents and challengers would be permitted under this exception.

C. Meetings of Other Legislative Bodies

When a majority of the legislative body attends an open and noticed meeting of another legislative body of the same or a different local agency, the legislative body is not deemed to be conducting a meeting, so long as the members in attendance do not discuss, among themselves, other than as part of the scheduled meeting, issues of a specific nature related to the subject matter jurisdiction of the body. (§ 54952.2(c)(4).) Thus, when a majority of a planning commission attends a meeting of the city council for the same city, it need not treat such attendance as a meeting of the planning commission for purposes of the Act. Similarly, when a majority of the members of a city council attend a meeting of the county board of supervisors, the city council is not conducting a meeting within the meaning of the Act. However, if two bodies conduct a joint meeting, each body should notice the meeting as a joint meeting of the two bodies. This exception, which is contained in section 54952.2(c)(4), does not apply when a majority of the members of a parent legislative body attend a meeting of a standing committee of the parent body. However, section 54952.2(c)(6) specifically addresses this issue. It provides that a majority of the parent body may attend an open and noticed meeting of a standing committee so long as the members who are not members of the standing committee and which cause a majority of the parent body to be present, attend only as observers. In 81 Ops.Cal.Atty.Gen. 156, 158 (1998), this office concluded that persons who attended solely as observers could not address the
committee by testifying, asking questions or providing information. In addition, the opinion concluded that observers could not sit at the dias.

D. Social or Ceremonial Occasions

Attendance by a majority of the members of the legislative body at a purely social or ceremonial occasion is not deemed to be a meeting, so long as the members do not discuss among themselves specific business within the jurisdiction of the body. (§ 54952.2(c)(5).) This has long been the law in California. (Sacramento Newspaper Guild v. Sacramento County Bd. of Suprs. (1968) 263 Cal.App.2d 41; 43 Ops.Cal.Atty.Gen. 36, 38 (1964).) In practice, this prohibition may sometimes be difficult to observe since persons attending social or ceremonial occasions frequently wish to discuss specific issues with their governmental officials. However, where a majority of a legislative body is present, the members must not discuss specific business within the jurisdiction of the body to avoid violating the Act.

2. Serial Meetings

The issue of serial meetings stands at the vortex of two significant public policies: first, the constitutional right of citizens to address grievances and communicate with their elected representatives; and second, the Act’s policy favoring public deliberation by multi-member boards, commissions and councils. The purpose of the serial meeting prohibition is not to prevent citizens from communicating with their elected representatives, but rather to prevent public bodies from circumventing the requirement for open and public deliberation of issues.

The Act expressly prohibits serial meetings that are conducted through direct communications, personal intermediaries or technological devices for the purpose of developing a concurrence as to action to be taken. (§ 54952.2(b); Stockton Newspapers, Inc. v. Redevelopment Agency (1985) 171 Cal.App.3d 95, 103.) This provision raises two questions: first, what is a serial meeting for purposes of this definition; and second, what does it mean to develop a concurrence as to action to be taken.

Typically, a serial meeting is a series of communications, each of which involves less than a quorum of the legislative body, but which taken as a whole involves a majority of the body’s members. For example, a chain of communications involving contact from member A to member B who then communicates with member C would constitute a serial meeting in the case of a five-person body. Similarly, when a person acts as the hub of a wheel (member A) and communicates individually with the various spokes (members B and C), a serial meeting has occurred. In addition, a serial meeting occurs when intermediaries for board members have a meeting to discuss issues. For example, when a representative of member A meets with representatives of members B and C to discuss an agenda item, the members have conducted a serial meeting through their representatives as intermediaries. The statutory definition also applies to situations in which technological devices are used to connect people at the same time.
who are in different locations (but see the discussion below concerning the exception for teleconference meetings).

Once serial communications are found to exist, it must be determined whether the communications were used to develop a concurrence as to action to be taken. If the serial communications were not used to develop a concurrence as to action to be taken, the serial communications do not constitute a meeting and the Act is not applicable. In construing these terms, one should be mindful of the ultimate purposes of the Act -- to provide the public with an opportunity to monitor and participate in the decision-making processes of boards and commissions. As such, substantive conversations among members concerning an agenda item prior to a public meeting probably would be viewed as contributing to the development of a concurrence as to the ultimate action to be taken. Conversations which advance or clarify a member’s understanding of an issue, or facilitate an agreement or compromise among members, or advance the ultimate resolution of an issue, are all examples of communications which contribute to the development of a concurrence as to action to be taken by the legislative body. Accordingly, with respect to items that have been placed on an agenda or that are likely to be placed upon an agenda, members of legislative bodies should avoid serial communications of a substantive nature concerning such items.

Problems arise when systematic communications begin to occur which involve members of the board acquiring substantive information for an upcoming meeting or engaging in debate, discussion, lobbying or any other aspect of the deliberative process either among themselves or with staff. For example, executive officers may wish to brief their members on policy decisions and background events concerning proposed agenda items. This office believes that a court could determine that such communications violate the Act, because such discussions are part of the deliberative process. If these communications are permitted to occur in private, a large part of the process by which members reach their decisions may have occurred outside the public eye. Under these circumstances, the public would be able only to witness a shorthand version of the deliberative process, and its ability to monitor and contribute to the decision-making process would be curtailed. Therefore, we recommend that when the executive director is faced with this situation, he or she prepare a memorandum outlining the issues for all of the members of the board as well as the public. In this way, the serial meeting violation may be avoided and everyone will have the benefit of reacting to the same information.

However, this office does not think that the prohibition against serial meetings would prevent an executive officer from planning upcoming meetings by discussing times, dates, and placement of matters on the agenda. It also appears that an executive officer may receive spontaneous input from any of the board members with respect to these or other matters so long as a quorum is not involved.
The express language of the statute concerning serial meetings largely codifies case law developed by the courts and the opinions issued by this office in the past. In *Frazer v. Dixon Unified School District* (1993) 18 Cal.App.4th 781, 796-798, the court concluded that the Act applies equally to the deliberations of a body and its decision to take action. If a collective commitment were a necessary component of every meeting, the body could conduct most or all of its deliberation behind closed doors so long as the body did not actually reach agreement prior to consideration in public session. Accordingly, the court concluded that the collective acquisition of information constituted a meeting. The court cited briefing sessions as examples of deliberative meetings which are subject to the Act’s requirements, and contrasted these sessions with activities that fall outside the purview of the Act, such as the passive receipt of an individual’s mail or the solitary review of a memorandum by an individual board member.

In *Stockton Newspapers, Inc. v. Redevelopment Agency* (1985) 171 Cal.App.3d 95, 105, the court concluded that a series of individual telephone calls between the agency attorney and the members of the body constituted a meeting. In that case, the attorney individually polled the members of the body for their approval on a real estate transaction. The court concluded that even though the meeting was conducted in a serial fashion, it nevertheless was a meeting for the purposes of the Act. (See also, 65 Ops.Cal.Atty.Gen. 63, 66 (1982); 63 Ops.Cal.Atty.Gen. 820, 828-829 (1980).)

### 3. Individual Contacts Between Members of the Public and Board Members

The prohibition against serial meetings must be reconciled with the exemption for individual contacts and communications contained in section 54952.2(c)(1). Individual contacts or communications between a member of a legislative body and any other person are specifically exempt from the definition of a meeting. (§ 54952.2(c)(1).) The purpose of this exception appears to be to protect the constitutional rights of individuals to contact their government representatives regarding issues which concern them. To harmonize this exemption with the serial meeting prohibition, the term “any other person” is construed to mean any person other than a board member or agency employee. Thus, while this provision exempts from the Act’s coverage conversations between board members and members of the public, it does not exempt conversations among board members, or between board members and their staff.

By using the words “individual contacts or conversations” it appears that the Legislature was attempting to ensure that individual contacts would not be defined as a meeting, while still preventing the members of a body from orchestrating contacts between a private party and a quorum of the body. Accordingly, if a member of the public requests a conversation with an individual member of the board, who then acts independently of the board and its other members in deciding whether to talk with the member of the public, no meeting will have occurred even if the member of the public ultimately meets with a quorum of the body.
4. Teleconference Meetings

The prohibition against serial meetings specifically exempts teleconference meetings conducted according to the procedures set forth in section 54953(b). All other teleconference meetings are prohibited. (§ 54952.2(b).)

A teleconference meeting is a meeting in which one or more members of the body attend the meeting from a remote location via electronic means, transmitting audio or audio/video. A meeting is not subject to the teleconference meeting requirements where only the staff members or other persons retained to advise the body appear from remote locations via audio or audio/visual transmission, where it is in the public interest to do so. A local agency may, at its discretion, permit the public to attend its meetings from additional remote locations.

Section 54953(b) authorizes the conduct of meetings by legislative bodies through teleconferencing under specified circumstances. Teleconferencing may be used for all purposes in conjunction with any meeting within the subject matter jurisdiction of the body. However, at least a quorum of the members of the body must participate from locations that are within the boundaries over which the body exercises jurisdiction. All votes taken during a teleconference meeting must be conducted by rollcall.

The biggest issue surrounding the use of teleconference meetings concerns the public’s access to the meeting. The Act requires that each teleconference location must be fully accessible to members of the public. This means that members of the body who choose to utilize their homes or offices as teleconference locations must open these locations to the public and accommodate any member of the public who wishes to attend the meeting at that location. Moreover, members of the public must be able to hear the meeting and testify from each location. Finally, the teleconference location must be accessible to the disabled. Because of these requirements, most agencies choose to utilize official or public meeting facilities for their remote teleconference sites.

When a body elects to use teleconferencing, it must post an agenda at each teleconference location and list each teleconference location in the notice and agenda. Each teleconference meeting must be conducted in such a manner so as to protect the statutory and constitutional rights of the public. Each teleconference meeting agenda must ensure the public’s right to testify at each teleconference location in accordance with section 54954.3.

In 84 Ops.Cal.Atty.Gen. 181 (2001), a disabled boardmember asked if, under the federal Americans with Disabilities Act, a body were required to utilize the teleconference meeting provisions to permit him to participate in a meeting where his disability prevented him from attending. In this situation, the public would not receive notice of the teleconference meeting location nor would they have access to the remote site from where the disabled member would attend. Under these circumstances, this office concluded that the teleconference provisions were not available because the public would not have access to the remote site.
5. **Writings as Meetings**

Historically, meetings have not commonly occurred through written instruments; however, the court found that circulation of a proposal among board members for their review and signature was found to be a meeting in violation of the Act when a majority of the members of a legislative body signed the document. (*Common Cause v. Stirling* (1983) 147 Cal.App.3d 518, 523-524.) However, the emergence of e-mail as a simple and effective means of communication has raised this issue in a fresh context. In 84 Ops.Cal.Atty.Gen. 30 (2001), this office concluded that a majority of a body would violate the Act if they e-mailed each other regarding current issues under the body’s jurisdiction even if the e-mails were also sent to the secretary and chairperson of the agency, the e-mails were posted on the agency’s Internet Web site, and a printed version of each e-mail was reported at the next public meeting of the body. The opinion concluded that these safeguards were not sufficient to satisfy either the express wording of the Act or some of its purposes. Specifically, such e-mail communications would not be available to persons who do not have Internet access. Even if a person had Internet access, the deliberations on a particular issue could be completed before an interested person had an opportunity to become involved.

In the case of *Roberts v. City of Palmdale* (1993) 5 Cal.4th 363, 381, the California Supreme Court stated that a memorandum from a body’s attorney to the members of the body did not constitute a meeting under the Act. The court concluded that this one-way memorandum, which represented a confidential attorney-client communication exempt from disclosure under the California Public Records Act, was outside the coverage of the Act. Under the California Public Records Act, the memorandum was expressly exempt from disclosure pursuant to section 6254(k). Had the members of the body sought to meet and discuss the memorandum, such a meeting would have been subject to the Act and could have been conducted in closed session only if it qualified under the pending litigation exception contained in section 54956.9. Any other conversations between the members of the body and the attorney concerning the exempt memorandum would be subject to the serial meeting restrictions discussed previously.

**CHAPTER IV.**

**NOTICE AND AGENDA REQUIREMENTS**

The Brown Act provides for three different types of meetings. Regular meetings occur at a time and location generally set by ordinance, resolution, or by-laws. At least 72 hours prior to a regular meeting, an agenda must be posted which contains a brief general description of each item to be transacted or discussed at the meeting. Special meetings may be called at any time but notice must be received at least 24 hours prior to the meeting by all members of the body and by all media outlets that have requested notice in writing. Emergency meetings, which are extraordinarily rare, may be called upon one-hour notice to media outlets that have requested notice in writing.
In addition to the pre-meeting notices and agendas discussed above, the Act requires two other types of disclosures. First, prior to meeting in closed session, a representative of the body must orally announce the items to be discussed in closed session. (§ 54957.7(a).) Generally, this requirement may be satisfied by referring to the numbered item on the agenda which describes the closed session in question. However, when the agency is meeting in closed session because of significant exposure to pending litigation as described in section 54956.9(b), the statement may need to include additional information as set forth in that section. (See discussion of pending litigation infra.)

Second, at the conclusion of each closed session, the agency must reconvene into open session. If any final decisions have been made in the closed-session meeting, a report may be required. (§ 54957.1.)

The Act also contains specific requirements with respect to adjourning or continuing meetings. (§§ 54955; 54955.1.) Lastly, unless specifically exempted, all meetings must be conducted within the geographical boundaries of the body’s jurisdiction. (§ 54954(b).)

1. Regular Meetings

Each legislative body, except for advisory bodies and standing committees, shall provide for the time and place for regular meetings by ordinance, resolution, or by-laws. (§ 54954(a).) If a body calls a meeting at a time or place other than the time or place specified for regular meetings, it is either a special or emergency meeting. Accordingly, the body must satisfy the appropriate notice requirement, and should indicate the type of meeting on the notice. Even where it is not required, the body may wish to provide additional notice in the form of the type of notice and agenda provided for a regular meeting.

Meetings of advisory bodies and standing committees for which 72-hour notice is provided, pursuant to section 54954.2, are considered regular meetings. (§ 54954(a).)

A. Agenda Requirement

At least 72 hours prior to a regular meeting, the body must post an agenda containing a brief general description of each item to be discussed or transacted at the meeting, including items to be discussed in closed session. (§ 54954.2(a).) The Act makes it clear that discussion items must be placed on the agenda, as well as items which may be the subject of action by the body.

The purpose of the brief general description is to inform interested members of the public about the subject matter under consideration so that they can determine whether to monitor or participate in the meeting of the body. In Carlson v. Paradise Unified School Dist. (1971) 18 Cal.App.3d 196, the court interpreted the agenda requirements
set forth in section 966 of the Education Code. That section required “... [a] list of items that will constitute the agenda for all regular meetings shall be posted...” (Carlson v. Paradise Unified School Dist. (1971) 18 Cal.App.3d 196, 199.) In interpreting this section, the court stated:

“In the instant case, the school board’s agenda contained as one item the language ‘Continuation school site change.’ This was entirely inadequate notice to a citizenry which may have been concerned over a school closure.

“On this point alone, we think the trial court was correct because the agenda item, though not deceitful, was entirely misleading and inadequate to show the whole scope of the board’s intended plans. It would have taken relatively little effort to add to the agenda that this ‘school site change’ also included the discontinuance of elementary education at Canyon View and the transfer of those students to Ponderosa School.” (Carlson v. Paradise Unified School Dist. (1971) 18 Cal.App.3d 196, 200, original emphasis; see also 67 Ops.Cal.Atty.Gen. 84, 87 (1984).)

However, the Legislature in section 54954.2 placed an important gloss on the requirement to provide a brief general description. That section expressly provides that the brief general description generally need not exceed 20 words in length. Thus, absent special circumstances, the legislative body may use a short description of less than 20 words to provide essential information about the item to members of the public. Where necessary, legislative bodies are free to provide a more detailed description, but as a general rule, they need not feel any obligation to do so (for more information about closed-session agenda description, see discussion infra).

In 78 Ops.Cal.Atty.Gen. 327, 331-332 (1995), this office concluded that the 72-hour notice requirement mandates local agencies to post their notices in locations which are accessible 24 hours a day for the 72 hours prior to the meeting. Accordingly, notices cannot be placed in buildings which are locked for some portion of the 72 hours immediately prior to the meeting.

The agenda requirement does not apply when certain unnoticed topics are discussed at a noticed meeting. For example, there is an exception for when a member of the body or a member of its staff, on his or her own initiative, or in response to a question from the public, asks a question for clarification, makes a brief announcement or makes a brief report on his or her own activities. (§ 54954.2(a).) In addition, any member of the body or the body as a whole, subject to rules or procedures of the legislative body, may provide a reference to staff or other resources for factual information, request staff
to report back to the body at a subsequent meeting concerning any matter, or take 
action to direct staff to place a matter of business on a future agenda. (§ 54954.2(a).)

Section 54954.2 also contains specific procedures by which the agenda requirement 
may be avoided in other specified circumstances as well. (§ 54954.2(b).)

B. Exceptions to Agenda Requirements

The Act identifies three situations in which a body is permitted to discuss or take action 
on a matter at a regular meeting where the matter was not first described on a duly 
noticed agenda. (§ 54954.2(b).) Prior to discussing a matter which was not previously 
placed on an agenda, the item must be publicly identified so that interested members 
of the public can monitor or participate in the consideration of the item in question.

The body may discuss a nonagenda item at a regular meeting if, by majority vote, the 
body determines that the matter in question constitutes an emergency pursuant to 
section 54956.5. (§ 54954.2(b)(1).) Any discussion held pursuant to this exception 
must be conducted in open session, since emergency meetings held pursuant to section 
54956.5 cannot be conducted in closed session.

The body may discuss an item which was not previously placed upon an agenda at a 
regular meeting, when the body determines that there is a need for immediate action 
which cannot reasonably wait for the next regularly scheduled meeting. (§ 54954.2(b)(2).) 
However, the Act specifies that in order to take advantage of this 
agenda exception, the need for immediate action must have come to the attention of the 
local “agency” after the agenda had already been posted. (§ 54954.2(b)(2).) The 
Legislature’s choice of the term “agency” rather than “body” seems calculated to limit 
use of this exception by prohibiting its usage if the local agency, i.e. staff, and not 
merely the body, had knowledge of the situation requiring action prior to the posting 
of the agenda. Lastly, the determination that a need for immediate action exists must 
be made by two-thirds of the members present or, if two-thirds of the body is not 
present, by a unanimous vote of those remaining. (§ 54954.2(b)(2).)

Finally, where an item has been posted on an agenda for a prior meeting, the item may 
be continued to a subsequent meeting that is held within five days of the meeting for 
which the item was properly posted. Under these circumstances, the items need not be 
posted for the subsequent meeting. (§ 54954.2(b)(3); see also, §§ 54955-55.1 
[concerning adjournment and continuances], infra at p. 25.)

C. Public Testimony

Every agenda for a regular meeting shall provide an opportunity for members of the 
public to directly address the legislative body on any item under the subject matter
jurisdiction of the body. With respect to any item which is already on the agenda, or in connection with any item which the body will consider pursuant to the exceptions contained in section 54954.2(b), the public must be given the opportunity to comment before or during the legislative body’s consideration of the item. (§ 54954.3(a).) The public testimony requirement appears to apply to closed sessions as well as open meetings, but see section 11125.7(d) of the Bagley-Keene Act, concerning state bodies, which was added in 1993 to expressly provide otherwise. Accordingly, this office believes that it would be prudent for legislative bodies to afford the public an opportunity to comment on closed-session items prior to the body’s adjournment into closed session. The only exception to the public testimony requirement is where a committee comprised solely of members of the legislative body has previously considered the item at a public meeting in which all members of the public were afforded the opportunity to comment on the item before or during the committee’s consideration of it, so long as the item has not substantially changed since the committee’s hearing. (§ 54954.3(a).)

Where a member of the public raises an issue which has not yet come before the legislative body, the item may be briefly discussed but no action may be taken at that meeting. (§ 54954.3(a).) The purpose of the discussion is to permit a member of the public to raise an issue or problem with the legislative body or to permit the legislative body to provide information to the public, provide direction to its staff, or schedule the matter for a future meeting. (§ 54954.2(a).)

The Act specifically authorizes the legislative body to adopt regulations to assist in processing comments from the public. The body may establish procedures for public comment as well as specifying reasonable time limitations on particular topics or individual speakers. So long as the body acts fairly with respect to the interest of the public and competing factions, it has great discretion in regulating the time and manner, as distinguished from the content, of testimony by interested members of the public. (§ 54954.3(b).)

When a member of the public testifies before a legislative body, the body may not prohibit the individual from criticizing the policies, procedures, programs or services of the agency or the acts or omissions of the legislative body. (§ 54954.3(c).) This provision does not confer on members of the public any privilege or protection not otherwise provided by law.

Public meetings of governmental bodies have been found to be limited public fora. As such, members of the public have broad constitutional rights to comment on any subject relating to the business of the governmental body. Any attempt to restrict the content of such speech must be narrowly tailored to effectuate a compelling state interest. Specifically, the courts found that policies that prohibited members of the public from criticizing school district employees were unconstitutional. (Leventhal v.
Vista Unified School Dist. (1997) 973 F.Supp. 951; Baca v. Moreno Valley Unified School Dist. (1996) 936 F.Supp. 719.) These decisions found that prohibiting critical comments was a form of viewpoint discrimination, and that such a prohibition promoted discussion artificially geared toward praising (and maintaining) the status quo, thereby foreclosing meaningful public dialogue.

In 78 Ops. Cal. Atty. Gen. 224, 230 (1995), this office opined that the body could prohibit a speaker from making comments that were outside the body’s jurisdiction. However, when applying this opinion, the body must take into account the court’s broad decisions as discussed above.

2. Special Meetings

Under the Act, the presiding officer or a majority of the body may call a special meeting. So long as substantive consideration of agenda items does not occur, a majority may meet without providing notice to the public in order to call the meeting and prepare the agenda. (216 Sutter Bay Associates v. County of Sutter (1997) 58 Cal.App.4th 860, 881-882.) Notice of a special meeting must be provided 24 hours in advance of the meeting to all of the legislative body members and to all media outlets who have requested notification. (§ 54956; 53 Ops. Cal. Atty. Gen. 245, 246 (1970).) The notice also must be posted at least 24 hours prior to the meeting in a location freely accessible to the public. The notice should indicate that the meeting is being called as a special meeting, and shall state the time, place, and business to be transacted at the meeting. No other business shall be considered at the special meeting. Notice is required even if the meeting is conducted in closed session, and, even if no action is taken. A member of the local body may waive failure to receive notice of the meeting by filing a written waiver prior to the meeting or by being present at the meeting.

At every special meeting, the legislative body shall provide the public with an opportunity to address the body on any item described in the notice before or during consideration of that item. (§ 54954.3(a).) The special meeting notice shall describe the public’s rights to so comment. (§ 54954.3(a).)

3. Emergency Meetings

When a majority of the legislative body determines that an emergency situation exists, it may call an emergency meeting. (§ 54956.5.) The Act defines an emergency as a crippling activity, work stoppage or other activity which severely impairs public health, safety or both. (§ 54956.5(a)(1).) Absent a dire emergency, telephonic notice must be provided to all media outlets that have requested that they receive notice of any special meetings called pursuant to section 54956 at least one hour prior to the meeting. (§ 54956.5(b).) In the case of a dire emergency, notice need only be provided at or near the time that notice is provided to the members of the body. (§ 54956.5(b).) A dire emergency is a crippling disaster, mass destruction, terrorist act, or threatened terrorist activity that poses peril so immediate and
significant that requiring a legislative body to provide one-hour notice before holding an emergency meeting may endanger the public health, safety, or both, as determined by a majority of the members of the legislative body. (§ 54956.5(a)(2).)

In the event telephone services are not working, the notice requirements are waived, but a report must be given to media outlets as soon as possible after the meeting. Except for the 24-hour notice requirement, the provisions of section 54956 relating to special meetings apply to the conduct of emergency meetings. (§ 54956.5(d).) At the conclusion of the meeting, the minutes of the meeting, a list of persons who the legislative body notified or attempted to notify, a copy of the rollcall vote, and any actions taken at the meeting shall be posted for a minimum of 10 days in a public place as soon after the meeting as possible. (§ 54956.5(e).)

As a general rule, emergency meetings may not be held in closed session. However, a legislative body may meet in closed session for purposes of consulting with law enforcement or security officials under section 54957 if agreed to by a two-thirds vote of the members of the legislative body present, or, if less than two-thirds of the members are present, by a unanimous vote of the members present. (§ 54956.5(c).)

4. Closed Sessions

There are three types of “notice” obligations that accompany the conduct of a closed-session as a part of a duly noticed meeting. First, each item to be transacted or discussed in a closed session must be briefly described on an agenda for the meeting. (§ 54954.2(a).) Second, prior to adjourning into closed session, a representative of the legislative body must orally announce the items to be discussed in closed session. (§ 54957.7(a).) This requirement may be satisfied by merely referring to the relevant portion of the written agenda for the meeting. However, the Act contains specific additional requirements for closed sessions regarding pending litigation where the body believes it is subject to a significant exposure to potential litigation. (§ 54956.9(b)(3).) Third, once the closed session has been completed, the agency must reconvene in open session, where it may be required to report votes and actions taken in closed session. (§ 54957.1.) These requirements are discussed in detail below.

A. Agenda Requirement

At least 72 hours prior to each regular meeting, legislative bodies must prepare an agenda containing a brief general description of each item to be transacted or discussed, including items which will be handled in closed session. (§ 54954.2(a).) A description of each item generally need not exceed 20 words, although the description must be sufficient to provide interested persons with an understanding of the subject matter which will be considered. (Carlson v. Paradise Unified School Dist. (1971) 18 Cal.App.3d 196, 200.) In the case of pending litigation, the legislative body must make reference in the agenda or publicly announce the specific subsection of section 54956.9 under which the closed session is being held. (§ 54956.9(c).)
In order to assist legislative bodies in preparing agendas for closed-session meetings, the Legislature enacted section 54954.5 which establishes a model format for closed-session agendas. Use of the model format is strictly voluntary on the part of the body. However, substantial compliance with the model format assures the legislative body that it will not be found in violation of the agenda requirements of section 54954.2. Substantial compliance with the model format in section 54954.5, therefore, provides a “safe harbor” from liability under the Act’s agenda requirements. Substantial compliance is satisfied by including the information contained in the model format, irrespective of the form in which it is ultimately presented. (§ 54954.5.)

The model format, which comprises the safe harbor provisions, adopts a fill-in-the-blank approach. The format is well suited to placement on a personal computer where descriptive information concerning specific agenda items can be inserted as appropriate. The safe harbor provisions concerning real property negotiations are set forth below and are illustrative of the format. (All of the safe harbor provisions are contained in the appendix in § 54954.5.)

(b) With respect to every item of business to be discussed in closed session pursuant to Section 54956.8:

CONFERENCE WITH REAL PROPERTY NEGOTIATORS

Property: (Specify street address, or if no street address, the parcel number or other unique reference, of the real property under negotiation)

Agency negotiator: (Specify names of negotiators attending the closed session) (If circumstances necessitate the absence of a specified negotiator, an agent or designee may participate in place of the absent negotiator so long as the name of the agent or designee is announced at an open session held prior to the closed session.)

Negotiating parties: (Specify name of party (not agent))

Under negotiation: (Specify whether instruction to negotiator will concern price, terms of payment, or both)

It is noteworthy that the closed-session provisions concerning negotiations specifically require the body to identify the individuals who will be attending the closed session as negotiators. (§§ 54956.8; 54957.6)
The safe harbor provisions concerning litigation and personnel have been tailored to protect the confidentiality interests of the agency, and employees who potentially are the subject of discipline. Thus, the safe harbor provisions require less specificity when the agenda deals with such matters.

Although the safe harbor provisions are primarily designed to fulfill the agenda requirements for regular meetings, the provisions also can be used in connection with closed sessions at special meetings called pursuant to section 54956. (§ 54954.5.)

B. Oral Announcement Prior to Closed Sessions

In addition to the agenda requirement for regular and special meetings, the Act requires a representative of the legislative body to orally announce the items to be discussed in closed session prior to any closed-session meeting. (§ 54957.7(a).) This requirement may be satisfied by referring to the item by number as it appears on the agenda.

However, such a referral usually would not be sufficient in the case of a closed session concerning significant exposure to litigation.

Pursuant to section 54956.9, a closed session may be conducted in order to permit an agency to receive advice from its legal counsel. When the impetus for such a closed session is the agency’s exposure to potential litigation, the Act carefully regulates the circumstances under which a closed session may be called, and the types of announcement which must accompany such a meeting. (§ 54956.9(b)(3).) These required disclosures may be made as a part of the written agenda or as a part of the oral announcement made prior to any closed session. These requirements do not mandate disclosure of privileged communications exempt from disclosure under the Public Records Act. (§ 54956.9(b)(3)(F).) A summary of the disclosure requirements surrounding closed sessions based on an agency’s exposure to potential litigation is set forth below.

- Where the agency believes that facts creating significant exposure to litigation are not known to potential plaintiffs, the facts need not be disclosed. (§ 54956.9(b)(3)(A).)

- Where facts (e.g., an accident, disaster, incident, or transaction) creating significant exposure to litigation are known to potential plaintiffs, the facts must be publicly stated on the agenda or announced. (§ 54956.9(b)(3)(B).)

- Where the agency receives a claim or other written communication threatening litigation, reference to the claim or communication must be publicly stated on the agenda or announced, and the claim or
communication must be available for public inspection pursuant to section 54957.5. (§ 54956.9(b)(3)(C).)

- Where a person makes a statement in an open and public meeting threatening litigation, reference to the statement must be publicly stated on the agenda or announced. (§ 54956.9(b)(3)(D).)

- Where a person makes a statement outside of an open and public meeting threatening litigation, the agency may not conduct a closed session unless an agency official having knowledge of the threat makes a contemporaneous or other record of the statement prior to the meeting. Reference to the statement must be publicly stated on the agenda or announced, and the record must be available for public inspection pursuant to section 54957.5. However, the record, or the disclosable part thereof, need not identify the alleged victim of unlawful or tortious sexual conduct or anyone making a threat on their behalf, or identify a public employee who is the alleged perpetrator of any such conduct, unless the identity of the person has been publicly disclosed. (§ 54956.9(b)(3)(E).)

C. Report at the Conclusion of Closed Sessions

Once a closed session has been completed, the legislative body must convene in open session. (§ 54957.7(b).) If the legislative body took final action in the closed session, the body may be required to make a report of the action taken and the vote thereon to the public at the open session. (§ 54957.1(a).) The report may be made either orally or in writing. (§ 54957.1(b).) In the case of a contract or settlement of a lawsuit, copies of the document also must be disclosed as soon as possible. (§ 54957.1(b) and (c).) If final action is contingent upon another party, the legislative body is under no obligation to release a report about the closed session. Once the other party has acted, making the decision final, the legislative body is under an obligation to respond to inquiries for information by providing a report of the action. (§ 54957.1(a).)

With respect to litigation, approval given to the body’s legal counsel to defend, to seek or refrain from seeking appellate review, or to appear as amicus curiae in any case resulting from a closed-session meeting held pursuant to section 54956.9 shall be reported in open session. (§ 54957.1(a)(2).) The report shall identify the adverse parties and the substance of the litigation. Where the body has decided to initiate litigation or intervene in an existing case, the report shall indicate that fact but need not identify the action, the parties, or other particulars. The report shall specify that once the litigation or intervention has been formally commenced, the body must, upon inquiry, disclose such information, unless to do so would jeopardize service of process or existing settlement negotiations. (§ 54957.1(a)(2).)
With respect to a personnel decision, any action taken to appoint or employ an individual must be reported at the meeting. Such a report would ordinarily include the name of the individual, but the Act specifically requires that the name of the position be reported. (§ 54957.1(a)(5).) In Gillespie v. San Francisco Pub. Library Comm’n (1998) 67 Cal.App.4th 1165, a library commission met in closed session to nominate three candidates for consideration by the mayor for appointment as city librarian. Plaintiff contended that the commission was required to announce the names of the nominees at the conclusion of the closed session. The court held that the requirement to announce appointments was not applicable because the commission had merely made a recommendation, not an appointment.

With respect to a dismissal or a refusal to renew an employment contract, the report shall be deferred until the first public meeting after the exhaustion of administrative remedies.

With respect to labor negotiations conducted pursuant to section 54957.6, the approval of an agreement concluding labor negotiations shall be reported after the agreement is final and has been accepted or ratified by the other party. The report shall identify the item approved and the other party or parties. (§ 54957.1(a)(6).)

No action for injury to a reputational, liberty, or other personal interest may be commenced by an employee or former employee based upon the report made by the legislative body in an attempt to comply with section 54957.1. (§ 54957.1(e).)

5. Adjournments and Continuances

Regular and special meetings may be adjourned to a future date. (§ 54955.) If the subsequent meeting is conducted within five (5) days of the original meeting, matters properly placed on the agenda for the original meeting may be considered at the subsequent meeting. (§ 54954.2(b)(3).) If the subsequent meeting is more than five (5) days from the original meeting, a new agenda must be prepared and posted pursuant to section 54954.2. Hearings continued pursuant to section 54955.1 are subject to the same procedures.

When a meeting is adjourned to a subsequent date, notice of the adjournment must be conspicuously posted on or near the door of the place where the meeting was held within 24 hours after the time of the adjournment. When less than a quorum of a body appears at a noticed meeting, the body may either meet as a committee of the parent body or adjourn to a future date pursuant to the provisions of sections 54955 or 54954.2(b)(3). If no members of the legislative body appear at a noticed meeting, the clerk may adjourn the meeting to a future date and provide notice to members of the legislative body and to the media in accordance with the special meeting notice provisions set forth in section 54956.
6. **Location of Meetings**

As a general rule, regular and special meetings shall be held within the boundaries of the territory over which the legislative body has jurisdiction. (§ 54954(b).) Accordingly, a city council must meet within the city; a county board of supervisors must meet within the county; and boards of directors for special districts must meet within the special district. Gatherings which are not meetings, as set forth in section 54952.2(c) (e.g., conferences, social activities, and attendance at open and public meetings held by others) are not subject to the Act, and therefore are not covered by the boundary restriction. In addition, the Act contains a number of specific exemptions from the boundary requirement. (§ 54954.) The fact that a meeting is exempt from the boundary requirement does not exempt the legislative body from the notice and open meeting requirements of the Act. A summary of the boundary exemptions is set forth below.

A legislative body must meet within its boundaries except to do any of the following:

- Comply with state or federal law or any court order. (§ 54954(b)(1).)
- Inspect real property located outside the jurisdiction or personal property which would be inconvenient to bring inside the jurisdiction. (§ 54954(b)(2).)
- Participate in meetings or discussions of multiagency significance so long as the meetings are held in the jurisdiction of one of the agencies and proper notice is provided by all bodies subject to the Act. (§ 54954(b)(3).)
- Meet in the nearest available facility if the legislative body has no meeting facility within the jurisdiction, or at the principal office of the legislative body if they are located outside the jurisdiction. (§ 54954(b)(4).)
- Meet with federal or California officials on a legislative or regulatory issue affecting the local agency and over which the state or federal officials have jurisdiction. (§ 54954(b)(5).)
- Meet in or nearby a facility owned by the local agency so long as the topic of the meeting is directly related to the facility itself. (§ 54954(b)(6).)
- Visit the office of the body’s legal counsel for a closed session held on pending litigation held pursuant to section 54956.9, when to do so would reduce legal fees or costs. (§ 54954(b)(7).)
In addition to the foregoing, governing boards of school districts have the following exemptions from the requirement to meet within their boundaries:

- Attend a conference on nonadversarial collective bargaining techniques. (§ 54954(c)(1).)
- Interview a potential employee from another district or interview the public from another district about the employment of a superintendent from that district. (§ 54954(c)(2) and (c)(3).)

Joint powers agencies must meet within the jurisdiction of one of its member agencies unless an exemption contained in section 54954(b) is applicable. (§ 54954(d).) A joint powers agency with members throughout the state may meet anywhere in the state.

Where a meeting place is unsafe because of emergency circumstances, the presiding officer of the legislative body shall designate the meeting place pursuant to specified notice requirements. (§ 54954(e).)

7. Special Procedures Regarding Taxes and Assessments

Section 54954.6 establishes a series of procedures which must be followed when a legislative body proposes new or increased taxes or assessments. These procedures are in addition to the notice and open meeting requirements contained elsewhere in the Act.

CHAPTER V.

RIGHTS OF THE PUBLIC

Under the Brown Act, a member of the public can attend a meeting of a legislative body without having to register or give other information as a condition of attendance. (§ 54953.3; see also 27 Ops.Cal.Atty.Gen. 123 (1956).) If a register, questionnaire or similar document is posted or circulated at a meeting, it must clearly state that completion of the document is voluntary and not a precondition for attendance. (§ 54953.3.) A legislative body may not prohibit any person attending an open meeting from video recording, audio recording or broadcasting the proceedings, absent a reasonable finding that such activity would constitute a disruption of the proceedings. (§§ 54953.5, 54953.6; Nevens v. City of Chino (1965) 233 Cal.App.2d 775, 779; see also § 6091.)

Under the Act, the public is guaranteed the right to provide testimony at any regular or special meeting on any subject which will be considered by the legislative body before or during its consideration of the item. (§ 54954.3(a).) In 80 Ops.Cal.Atty.Gen. 247, 248-252 (1997), this office concluded under a similar provision in the Bagley-Keene Act that the public’s right to comment on all agenda items
applied to quasi-judicial proceedings as well as quasi-legislative proceedings. In addition, the public has the right at every regular meeting to provide testimony on any matter under the legislative body’s jurisdiction. (§ 54954.3(a).) However, this office concluded that a body could prohibit a member of the public from speaking on a matter that was outside the jurisdiction of the body. (78 Ops.Cal.Atty.Gen. 224, 230 (1995).)

The Act specifically authorizes the legislative body to adopt regulations to assist in processing comments from the public. The body may establish general procedures for public comment as well as specifying reasonable time limitations on particular topics or individual speakers. So long as the body acts fairly with respect to the interest of the public and competing factions, it has great discretion in regulating the time and manner, as distinguished from the content, of testimony by interested members of the public. (§ 54954.3(b).)

The Act provides that the legislative body shall not prohibit a member of the public from criticizing the policies, procedures, programs, or services of the agency, or of the acts or omissions of the legislative body. (§ 54954.3(c).) Public meetings of governmental bodies have been found to be limited public fora. As such, members of the public have broad constitutional rights to comment on any subject relating to the business of the governmental body. Any attempt to restrict the content of such speech must be narrowly tailored to effectuate a compelling state interest. Specifically, the courts found that policies that prohibited members of the public from criticizing school district employees were unconstitutional. (Leventhal v. Vista Unified School Dist. (1997) 973 F.Supp. 951; Baca v. Moreno Valley Unified School Dist. (1996) 936 F.Supp. 719.) These decisions found that prohibiting critical comments was a form of viewpoint discrimination, and that such a prohibition promoted discussion artificially geared toward praising (and maintaining) the status quo, thereby foreclosing meaningful public dialogue.

Despite the public’s rights to attend meetings as discussed above, a legislative body may exclude all persons who willfully cause a disruption of a meeting so that it cannot be conducted in an orderly fashion. Where removal of the disruptive persons is not sufficient to restore order, the body may clear the room of all persons. (§ 54957.9.) However, in such situations, media personnel not involved in the disturbance must be permitted to attend the session as continued. (§ 54957.9.)

Agendas or any other writings, except for records exempt from disclosure under section 6254 of the Public Records Act, distributed to all or a majority of the members of a legislative body for discussion or consideration at a public meeting are disclosable to the public upon request, and shall be made available without delay to members of the public in accordance with the provisions of section 54957.5. If materials are provided prior to a meeting, the materials should, upon request and without delay, be made available to the public upon request at the time of distribution to the body. (§ 54957.5(a).) If the materials are distributed to the members of the body by the agency at the meeting, the materials should be available to the public at that time as well. Materials provided at the meeting by a person, who is not a member of the body or employee of the local agency, must be made available by the body to the public at the conclusion of the meeting. (§ 54957.5(b).)
Members of the public who make written requests for documents which were finally approved in a closed session generally may receive copies of such documents at the conclusion of the meeting. (§ 54957.1(b).) This right to obtain documents does not include documents which are exempt from disclosure pursuant to section 6254 of the Public Records Act. (Roberts v. City of Palmdale (1993) 5 Cal.4th 363, 370-373; Cal.Atty.Gen., Indexed Letter, No. IL 77-67 (April 28, 1977).) Pursuant to section 6253(c), a fee equal to the direct cost of duplication may be charged to any person requesting a copy of a public record. (§ 54957.5(c)); North County Parents Organization for Children with Special Needs v. California Department of Education (1994) 23 Cal.App.4th 144, 147-148.) In the North County case, the court indicated that a pro rata share of equipment and conceivably personnel expenses directly involved in actually duplicating a record could be included in calculating the fee. However, research and retrieval costs may not be included in the fee. Thus, the direct cost of actually photocopying a record may be recovered, but associated costs such as the cost of research, redaction and retrieval may not be recovered.

In addition, members of the public may request in writing that the agenda or all of the documents comprising the meeting packet be mailed to them for a cost not to exceed the actual cost of providing the service. (§ 54954.1.) Upon receipt of such a written request, the agency shall mail the requested documents, provided that they are not exempt from disclosure pursuant to section 6254, to the requester at the time the agenda is posted or when the documents are provided to a majority of the members of the legislative body, whichever occurs first. The request must be renewed annually and failure of the requester to receive such documents does not invalidate any action which was the subject of the records.

If an agency records an open meeting either on video or audio tapes, the tapes and a tape recorder must be made available to the public if a request is made. (§ 54953.5(b).) The agency is not required to prepare a transcript, but if one were prepared, the public generally would have the right to receive copies upon request. (64 Ops.Cal.Atty.Gen. 317, 321 (1981).) If the agency wishes to destroy the tapes after 30 days, it may do so without regard to the limitations imposed by section 34090. (§ 54953.5(b).)

Except as specifically authorized by the Act, the legislative body may not impose fees to defray its costs in carrying out the provisions of the Act. (§ 54956.6.)

A legislative body may not conduct any meeting or function in any facility where racial or other discrimination is practiced, or which is inaccessible to disabled persons, or where members of the public must pay to attend the meeting. (§ 54961.) A facility is accessible if it fully satisfies the accessibility requirements of Government Code section 4450 et seq. or Health and Safety Code section 19955 et seq., as well as the federal Americans with Disabilities Act of 1990. (§ 54953.2) If a meeting facility is inaccessible, the meeting must be moved to an accessible facility.

The Act requires that agendas, agenda packets, and other writings distributed to members of a legislative body be made available in appropriate alternative formats to persons with a disability and that the agendas include information on the availability of disability-related aids or services to enable
the person to participate in the public meeting consistent with the Americans with Disabilities Act. (§§ 54954.1, 54954.2, 54957.5.) Legislative bodies may go beyond the minimal requirements of the Act and provide greater public access to their meetings. (§ 54953.7.) Elected legislative bodies may impose greater access requirements on agencies under their jurisdiction. (§ 54953.7.)

CHAPTER VI.

PERMISSIBLE CLOSED SESSIONS

1. Introduction

A. Narrow Construction

Under the Brown Act, closed sessions must be expressly authorized by explicit statutory provisions. Prior to the enactment of section 54962, the courts and this office had recognized impliedly authorized justifications for closed sessions. (Sutter Sensible Planning, Inc. v. Board of Supervisors (1981) 122 Cal.App.3d 813; Sacramento Newspaper Guild v. Sacramento County Bd. of Suprs. (1968) 263 Cal.App.2d 41.) However, that legislation made it clear that closed sessions cannot be conducted unless they are expressly authorized by statute. Although confidential communication privileges continue to exist in other statutes such as the Public Records Act and Evidence Code section 1040, these provisions no longer can impliedly authorize a closed session.

Since closed sessions are an exception to open meeting requirements, the authority for such sessions has been narrowly construed. The law evinces a strong bias in favor of open meetings, and court decisions and opinions of this office have buttressed that legislative intent. (§ 54950.) The fact that material may be sensitive, embarrassing or controversial does not justify application of a closed session unless it is authorized by some specific exception. (Rowen v. Santa Clara Unified School District (1981) 121 Cal.App.3d 231, 235.) Rather, in many circumstances these characteristics may be further evidence of the need for public scrutiny and participation in discussing such matters. (See Civ. Code, § 47(b) [regarding privileged publication of defamatory remarks in a legislative proceeding].)

In 61 Ops.Cal.Atty.Gen. 220, 226 (1978), we concluded that meetings of the Board of Police Commissioners could not, as a general proposition, be held in closed session, even though the matters to be discussed were sensitive and the commission considered their disclosure contrary to the public interest.
The Act does not contain a general exemption for quasi-judicial deliberations, and this office concluded that such an exemption was not generally authorized by implication. In 71 Ops.Cal.Atty.Gen. 96, 106 (1988), this office concluded that the deliberations of a hearing board of an air pollution control district, after it has conducted a public hearing on a variance, order of abatement or permit appeal, must be conducted in public. The opinion further stated that the board was prohibited from conducting such deliberations in a closed session with the board’s counsel or the board’s attorney member. Similarly, in 57 Ops.Cal.Atty.Gen. 189, 192 (1974), this office opined that county boards of education could not meet in closed session to deliberate when deciding appeals from decisions of local school boards refusing to enter into interdistrict attendance agreements.

B. Semi-Closed Meetings

In 46 Ops.Cal.Atty.Gen. 34, 35 (1965), this office also concluded that meetings could not be semi-closed. Thus, certain interested members of the public may not be admitted to a closed session while the remainder of the public is excluded. Nor would it be proper for an investigative committee of a grand jury performing its duties of investigating the county’s business to be admitted to a closed session. (Cal.Atty.Gen., Indexed Letter, No. IL 70-184 (October 9, 1970).) As a general rule, closed sessions may involve only the membership of the body in question plus any additional support staff which may be required (e.g., attorney required to provide legal advice; supervisor or witnesses may be required in connection with disciplinary proceeding; labor negotiator required for consultation). Persons without an official role in the meeting should not be present.

C. Secret Ballots

Secret ballots are expressly prohibited by section 54953(c). This office has long disapproved secret ballot voting in open meetings and the casting of mail ballots. Thus, items under consideration which are not subject to a specific closed meeting exception must be conducted in a fully open forum. (68 Ops.Cal.Atty.Gen. 65 (1985).) One aspect of the public’s right to scrutinize and participate in public hearings is their right to witness the decision-making process. If votes are secretly cast, the public is deprived of a portion of its right. (See also 59 Ops.Cal.Atty.Gen. 619, 621-622 (1976).) However, it is the view of this office that members of a body may cast their ballots either orally or in writing so long as the written ballots are marked and tallied in open session and the ballots are disclosable public records.
D. Confidentiality of Closed Session

Section 54963 provides that a person may not disclose confidential information that has been acquired by attending a proper closed session to a person not entitled to receive it, unless the disclosure is authorized by the legislative body.

For purposes of this section, “confidential information” means a communication made in a closed session that is specifically related to the basis for the legislative body to meet lawfully in closed session.

If this prohibition is violated, it may be enforced by relying upon current available legal remedies including the following:

- Injunctive relief to prevent the disclosure of confidential information.
- Disciplinary action against an employee who has willfully disclosed confidential information in violation of this prohibition. Such disciplinary action must be first preceded by training or notice of the prohibition.
- Referral of a member of a legislative body who has willfully disclosed confidential information to the grand jury.

However, section 54963 provides that no action may be taken against a person for any of the following:

- Making a confidential inquiry or complaint to a district attorney or grand jury concerning a perceived violation of law, including disclosing facts that are necessary to establish the illegality of an action taken by a legislative body or the potential illegality of an action that has been the subject of deliberation at a closed session if that action were ultimately to be taken by the legislative body.
- Expressing an opinion concerning the propriety or legality of actions taken by a legislative body in closed session, including disclosure of the nature and extent of the illegal or potentially illegal action.
- Disclosing information acquired by being present in a closed session that is not confidential information.
- Disclosing information under the whistle blower statutes contained in Labor Code section 1102.5 or Government Code section 53296.
(See *Kleitman v. Superior Court* (1999) 74 Cal.App.4th 324, 335, fn. 9 [where the court found that the contents of a closed session were privileged information and applied Evidence Code 1040(b)(1), which provides an absolute privilege for confidential government information to prevent compelled disclosure in a civil proceeding]; 76 Ops.Cal.Atty.Gen. 289, 290-291 (1993); 80 Ops.Cal.Atty.Gen. 231, 235 (1997).)

2. **Authorized Exceptions**

All closed sessions must be conducted pursuant to expressly authorized statutory exceptions. (§ 54962.) As stated previously, the closed session exception to open meeting laws has been narrowly construed by the courts.

A. **Personnel Exception**

The purpose of the personnel exception is to avoid undue publicity or embarrassment for public employees and to allow full and candid discussion of such employees by the body in question. (*Fischer v. Los Angeles Unified School Dist.* (1999) 70 Cal.App.4th 87, 96; *San Diego Union v. City Council* (1983) 146 Cal.App.3d 947, 955; 61 Ops.Cal.Atty.Gen. 283, 291 (1978).) Accordingly, the Act provides for closed sessions regarding the appointment, employment, evaluation of performance, discipline or dismissal of a public employee. (§ 54957.)

In *Gillespie v. San Francisco Pub. Library Comm’n* (1998) 67 Cal.App.4th 1165, the Library Commission conducted a closed-session meeting to consider appointment of a new city librarian. Although the mayor actually makes the appointment, the city charter requires the Library Commission to participate in the appointment process. The court held that the Commission’s closed-session meeting under the personnel exception for the purpose of nominating three candidates for consideration by the mayor was proper.

In 80 Ops.Cal.Atty.Gen. 308, 311 (1997), this office concluded that the personnel exception could be utilized by an advisory committee created by a school district to provide it with recommendations on the employment of a new superintendent after conducting interviews and deliberations on the applicants. However, a body may not conduct a closed session where it is not assigned responsibility in connection with the decision. Accordingly, this office concluded that a county board of education may not conduct a closed session on a personnel decision where that decision rested solely with the superintendent, and not with the board. (85 Ops.Cal.Atty.Gen. 77 (2002).)

Under the Act, an employee may request and require a public hearing where the purpose of the closed session is to discuss specific charges or complaints against the employee. Under the Act, the employee must be given at least 24-hour written notice
of any meeting to hear specific charges or complaints against the employee, or any action taken at the meeting will be null and void. (§ 54957.)

In *Fischer v. Los Angeles Unified School Dist.* (1999) 70 Cal.App.4th 87, 100, the court determined that an employee had the right to receive the 24-hour notice only when the body was considering complaints and charges brought by a third person or an employee. The court specifically distinguished these hearings concerning complaints or charges from closed-session meetings to consider the appointment, employment, evaluation of performance, discipline or dismissal of an employee. In these latter instances, the court indicated that the body need not provide 24-hour notice to the individuals in question. Thus, when complaints or charges are not pending, this office opined that the Act permits the holding of a closed session to discuss an employee’s job performance irrespective of the employee’s desires. (61 Ops.Cal.Atty.Gen. 283, 291(1978).) In *Duval v. Board of Trustees* (2001) 93 Cal.App.4th 902, 909-910, the court found that an employee evaluation could – be comprehensive or focus on specific instances of conduct; include consideration of the process to be followed in conducting the evaluation; provide feedback to the employee; and, establish goals for future performance.

In *Fischer v. Los Angeles Unified School Dist.* (1999) 70 Cal.App.4th 87, 101-102, the court concluded that charges or complaints brought against a person generally involve something in the nature of an accusation. An evaluation of performance conducted in the normal course of the employer’s business usually does not involve communications resembling an accusation. Thus, a review of a probationary employee to determine whether permanent status will be conferred does not involve complaints or charges since no cause need be shown, no reason given and no appeal granted. Under these circumstances, the employee has no right to be present in a closed session to consider whether to grant permanent status. (See also 78 Ops.Cal.Atty.Gen. 218 (1995) [review of evaluation and denial of tenure]; *Furtado v. Sierra Community College* (1998) 68 Cal.App.4th 876 [review of evaluation and dismissal of nontenured employee].) These reviews of probationary teachers retain their evaluative nature even though allegations of misconduct may be a part of the evaluation. These citations are in contrast to *Bell v. Vista Unified School Dist.* (2000) 82 Cal.App.4th 672, where the school superintendent brought a complaint against a teacher before the school board in a context unrelated to a performance evaluation. In that case, the court found that the 24-hour notice was required.

In *Bollinger v. San Diego Civil Service Comm.* (1999) 71 Cal.App.4th 568, an employee was demoted. The demotion was appealed and a hearing officer conducted a hearing and prepared a report for the full reviewing body to consider in closed session. The employee contended that he should have been provided with 24-hour notice of the hearing officer’s report and his right to make the hearing public. The court concluded that the body was not hearing complaints or charges, but was merely
deliberating after a proper evidentiary proceeding had been conducted by the hearing officer. The court found that the employee had the opportunity to contest or present any information during the hearing, and therefore, neither due process nor the Brown Act required that he receive notice prior to the closed session. The court found that, as a general matter, the language of the Act and the legislative history supported the conclusion that a body may deliberate in closed session after a public hearing to hear charges and complaints.

Care must be exercised to analyze the status of the individual involved in a closed session subject to the personnel exception. If the person is not an “employee,” all action must be taken in public session. The Act defines the term “employee” to include an officer or an independent contractor who functions as an officer or an employee, but shall not include any elected official, member of a legislative body or other independent contractors. (§ 54957.) Thus, the personnel exception not only applies to civil service employees or their equivalent, it includes department heads and other high-ranking local officers. The exception applies to such officials irrespective of whether they are appointed to an office or merely serve by contract (e.g., contract city attorney). The key issue is whether the individual functions under the normal supervision and reporting requirements for an officer or employee, as opposed to that of an independent contractor who performs a task free of such day to day constraints. Accordingly, an independent contractor who performs a study or constructs a building or project must be selected in an open session of the legislative body. (See, e.g., Rowen v. Santa Clara Unified School District (1981) 121 Cal.App.3d 231, 233 [which concluded under prior law that discussions regarding the qualifications of an independent contractor to sell surplus land for the district should have been conducted in public].)

In no case does the term “employee” include elected officers or persons appointed to fill a vacancy of an elected office. Elected officers who are separately appointed to preside over their boards are not employees within the meaning of the Act. Therefore, complaints against such presiding officers may not be discussed in a closed session. (See also 61 Ops.Cal.Atty.Gen. 10 (1978).)

The courts and this office have consistently maintained that the personnel exception must be used in connection with the consideration of a particular employee. The exemption is not available for across-the-board decisions or evaluations of employees, classifications and salary structures. In Santa Clara Federation of Teachers v. Governing Board (1981) 116 Cal.App.3d 831, 846, the court concluded that a board’s consideration of a hearing officer’s decision concerning teacher layoff policy must be conducted in open session.

In 63 Ops.Cal.Atty.Gen. 153 (1980), we concluded that abstract discussions concerning the creation of a new administrative position and the workload of existing positions
were inappropriate for a closed session. However, had the workload discussions involved the evaluation of the performance of specific employees, a closed session would have been proper for that portion of the discussion.

In *Lucas v. Board of Trustees* (1971) 18 Cal.App.3d 988, 990, the court determined that a decision not to rehire a district superintendent of a high school district was properly made in closed session. Also, in 59 Ops.Cal.Atty.Gen. 532, 536 (1976), we concluded that the use of a closed session by a school district governing board to discuss and evaluate the performance of its superintendent was appropriate. In both situations, the superintendent was found to be an “employee.”

In *San Diego Union v. City Council* (1983) 146 Cal.App.3d 947, the court broke new ground in delineating the subjects which are appropriate for consideration in closed sessions under the personnel exception. There, the court considered whether the city council could meet in closed session to discuss the job performances and salary levels of certain employees. The court concluded that a closed session was appropriate for the purpose of reviewing an employee’s job performance and making the threshold decision of whether any salary increase should be granted. However, all discussions concerning the amount of any salary increase should be held in public session.

The court specifically rejected the argument that the terms “employment” or “performance” as used in section 54957 should be interpreted to include salary level determinations. The court stated, “Salaries and other terms of compensation constitute municipal budgetary matters of substantial public interest warranting open discussion and eventual electoral public ratification.” (*San Diego Union v. City Council* (1983) 146 Cal.App.3d 947, 955.) The court stated that although an individual’s job performance could be considered in closed session, there were a variety of other factors that must be considered in determining the appropriate salary level (e.g., availability of funds; other funding priorities; relative compensation of similar positions elsewhere, both inside and outside of the jurisdiction).

The *San Diego Union* decision has now been codified in section 54957, which states, “[C]losed sessions held pursuant to this section shall not include discussion or action on proposed compensation except for a reduction of compensation that results from the imposition of discipline.” Although the amount of any proposed increase in an employee’s compensation may not be considered in closed session, the employee’s job performance may be discussed in closed session, including the threshold decision of whether the employee should receive a raise.

To the extent there are bona fide negotiations between a legislative body and an unrepresented individual who is a current or prospective employee of the body, the body may meet with its representative to provide instructions on how to conduct the negotiations. (§ 54957.6.) However, if the board is merely setting the salary without
entering into bona fide negotiations, this section is inapplicable. The instructions to
the negotiator may include consideration of an agency’s available funds and funding
priorities, insofar as such discussions relate to providing instructions to the local
agency’s negotiator. However, closed sessions under section 54957.6 may not include
a final decision concerning an unrepresented employee’s compensation.

B. Pending Litigation and the Attorney-Client Privilege

(1) Historical Background

In 1953, the Legislature enacted the Act but did not make any provisions for
closed sessions in connection with litigation or the attorney-client privilege. In 1968, the court, in Sacramento Newspaper Guild v. Sacramento County Bd. of Suprs. (1968) 263 Cal.App.2d 41, 57, reasoned that the Act was not intended
to impliedly repeal preexisting and well-established laws relating to privileges
and confidentiality. Accordingly, the attorney-client privilege impliedly
authorized closed sessions for legislative bodies to confer with their attorneys.

In 1984, the Legislature enacted SB 2216, chapter 1126, which added section
54956.9 to the Act. That section expressly authorized closed sessions in
connection with pending litigation and created specific procedures and
definitions for implementing these closed sessions.

In 1987, the Legislature enacted SB 200, chapter 1320, to provide that the
expressly authorized exemption regarding pending litigation is the exclusive
expression of the attorney-client privilege for purposes of conducting closed-
session meetings. The legislation also provided that no closed session may be
held unless it is expressly authorized by statute. (§ 54962.) This provision
means that other confidentiality privileges may not be relied upon as implicit
authorization for closed sessions.

(2) Pending Litigation Exception

The codified pending litigation exception relating to local bodies is contained
in section 54956.9. This section authorizes bodies to conduct closed sessions
with their legal counsel to discuss pending litigation when discussion in open
session would prejudice the agency in that litigation. “Litigation” includes any
adjudicatory proceeding, including eminent domain, before a court,
administrative body, hearing officer or arbitrator. For the purpose of this
section, litigation is pending when any of the following occurs: litigation to
which the agency is a party has been initiated formally (§ 54956.9(a); 69
initiates an adjudicatory proceeding]; the agency has decided or is meeting to
decide whether to initiate litigation (§ 54956.9(c); or in the opinion of the legislative body on advice of its legal counsel, there is a significant exposure to litigation if matters related to specific facts and circumstances are discussed in open session (§ 54956.9(b)(1). Agencies are also authorized to meet in closed session to consider whether a significant exposure to litigation exists, based on specific facts and circumstances. (§ 54956.9(b)(2); see 71 Ops.Cal.Atty.Gen. 96, 105 (1988) [mere possibility of judicial review does not constitute significant exposure to litigation based on existing facts and circumstances].) For purposes of section 54956.9(b)(1) and (b)(2), “existing facts and circumstances” are specifically defined in section 54956.9(b)(3), along with the requirement to disclose certain information regarding the facts and circumstances prior to the holding of a closed session. (See Chapter IV, part 4(B) of this pamphlet for a description of the disclosure requirements.)

Existing facts and circumstances which create a significant exposure to litigation consist only of the following:

- The agency believes that facts creating significant exposure to litigation are not known to potential plaintiffs. (§ 54956.9(b)(3)(A).

- Facts (e.g., an accident, disaster, incident, or transaction) creating significant exposure to litigation are known to potential plaintiffs. (§ 54956.9(b)(3)(B).

- A claim or other written communication threatening litigation is received by the agency. (§ 54956.9(b)(3)(C).

- A person makes a statement in an open and public meeting threatening litigation. (§ 54956.9(b)(3)(D).

- A person makes a statement outside of an open and public meeting threatening litigation, and an agency official having knowledge of the threat makes a contemporaneous or other record of the statement prior to the meeting. (§ 54956.9(b)(3)(E).

Prior to conducting a closed session under the pending litigation exception, the body must state on the agenda or publicly announce the subdivision of section 54956.9 which authorizes the session. If litigation has already been initiated, the body must state the title of the litigation unless to do so would jeopardize service of process or settlement negotiations. (§ 54956.9(c).

In 75 Ops.Cal.Atty.Gen. 14, 20 (1992), this office concluded that the pending litigation exception could be invoked by a body to deliberate upon or take
action concerning the settlement of litigation. The court, in *Sacramento Newspaper Guild*, stated:

“In settlement advice, the attorney’s professional task is to provide his client a frank appraisal of strength and weakness, gains and risks, hopes and fears.” (*Sacramento Newspaper Guild* v. *Sacramento County Bd. of Suprs.* (1968) 263 Cal.App.2d 41, 56.)

Elaborating on this reasoning, this office’s opinion concluded:

“Unless section 54956.9 were given a strained and unnatural construction, the wording of the statute permits individual members of a legislative body not only to deliberate and exchange opinions with counsel but also among themselves in the presence of counsel. As we noted in 69 Ops.Cal.Atty.Gen. 232, 239, *supra*, the pending litigation exception fills the need to discuss confidentially with counsel ‘the strength and weaknesses of the local’ agency’s position in the litigation. And as articulated by the court in *Sacramento Newspaper Guild, Inc.*, *supra*, with respect to both ‘settlement and avoidance of litigation,’ these are ‘particularly sensitive activities, whose conduct would be grossly confounded, often made impossible, by undiscriminating insistence on open lawyer-client conferences.’ (263 Cal.App.2d at p. 56.)” (75 Ops.Cal.Atty.Gen. 14, 18-19 (1992).) (Original emphasis.)

The opinion went on to state that a body:

“. . . must be able to confer with its attorney and then decide in private such matters as the upper and lower limits with respect to settlement, whether to accept a settlement or make a counter offer, or even whether to settle at all. These are matters which will depend upon the strength and weakness of the individual case as developed from conferring with counsel. A local agency of necessity must be able to decide and instruct its counsel with respect to these matters in private.” (75 Ops.Cal.Atty.Gen. 14, 19-20 (1992).)

This interpretation is supported by section 54957.1(a)(3), which requires the body to disclose settlements where the body accepts a signed settlement agreement in closed session unless the agreement must be approved by another party or the court. Under the pending litigation exception, it appears that a
body generally must be a party or a potential party to litigation in order to meet in closed session with its attorney. In addition, it is possible that a legislative body may receive advice from its legal counsel concerning the body’s participation in litigation as an amicus curiae, even though the language of section 54956.9 does not clearly authorize a closed session in such circumstances. (§ 54957.1.) When a government entity such as a city or a county is sued, or when government officials such as a city council or a board of supervisors are sued in their official capacities, questions may arise concerning what other city or county entities or officials may be considered parties for purposes of the pending litigation exception. 67 Ops.Cal.Atty.Gen. 111, 116-117 (1984), which was issued prior to the enactment of section 54956.9, suggests that when the county is a party to a lawsuit, an advisory body to the board of supervisors on the general subject matter of the lawsuit also may be a party or a potential party for the purposes of conducting a closed-session meeting to receive advice from its attorney.

In 69 Ops.Cal.Atty.Gen. 232 (1986), this office considered the circumstances in which a decision by one city body to meet in public on matters related to pending litigation waived the right of all other bodies of that city to conduct closed sessions concerning the same pending litigation. Our opinion concluded that one city body’s decision to meet in public session regarding pending litigation is not necessarily a bar to other city bodies who wish to exercise their right to confer with their attorney in closed session. Specifically, we concluded that the city public works board did not and could not waive the city council’s right to meet with its attorney in closed session.

Lastly, it should be emphasized that the purpose of the pending litigation exception is to permit a body to meet with its attorney under certain defined circumstances. If the attorney is not present (either in person or by teleconference means), the closed session may not be conducted. It should also be emphasized that the purpose of the exception is to permit the body to receive legal advice and make litigation decisions only; it is not to be used as a subterfuge to reach nonlitigation oriented policy decisions. (71 Ops.Cal.Atty.Gen. 96, 104-105 (1988).)

Since the purpose of the pending litigation exception is to protect confidential attorney-client communications, our opinion in 62 Ops.Cal.Atty.Gen. 150 (1979) continues to be applicable insofar as it concluded that nonconfidential communications between an attorney and his or her client are not protected. In that opinion, two boards which were adversaries in a lawsuit, along with their counsel, sought to meet in closed session for purposes of negotiating a settlement to that lawsuit. Thus, it was the negotiations, rather than confidential communications between the lawyer and the client, which the
bodies sought to protect. Accordingly, we concluded that a closed session was not appropriate for these negotiations.

This office also concluded that Evidence Code section 1152 (which renders inadmissible for the purpose of proving liability, evidence of the conduct or statements of a litigant during settlement negotiations) does not authorize the holding of a joint closed session between two legislative bodies, engaged in litigation against each other, for the purpose of conducting settlement negotiations. Section 1152 has as its purpose the fostering of settlements of disputes rather than the protection of confidential communications. (62 Ops.Cal.Atty.Gen. 150, 154-155 (1979).)

Settlement negotiations, however, may be conducted by the attorneys for the respective litigating bodies, and a closed session, pursuant to the pending litigation exception, may be held by each body to consult with its attorney about the settlement. (62 Ops.Cal.Atty.Gen. 150, 154-155 (1979).)

It is important to remember that the requirements of the pending litigation exception only apply to communications in the context of a meeting. Written one way confidential attorney-client advice is not a meeting, and therefore, is not subject to the Brown Act. (Roberts v. City of Palmdale (1993) 5 Cal.4th 363; see page 15 of this pamphlet.) Also, negotiations conducted by a limited term ad hoc advisory committee comprised solely of less than a quorum of the body is not subject to the Act. (See page 5 of this pamphlet.) To the extent that either of these avenues is pursued one must be careful to avoid serial communications that would constitute a violation of the Act. (See page 11 of this pamphlet.)

C. Real Property Negotiations Exception

The Act contains provisions concerning the circumstances under which a body may meet in closed session to grant authority to its negotiator concerning the price and terms of payment in real property negotiations. (§ 54956.8.) Since the Act requires the body to report, at the conclusion of the closed session, the approval of an agreement concluding real property negotiations where the body’s action renders the agreement final, the body’s power to grant authority to its negotiator also includes the power to finalize any agreement so negotiated. (§§ 54956.8 and 54957.1.)

The exception for real property negotiations permits the body to meet in closed session to advise its negotiator concerning the “price” and “terms of payment” in connection with the purchase, sale, lease or exchange of property by or for the agency. In Kleitman v. Superior Court (1999) 74 Cal.App.4th 324, the court indicated that the purpose for the exception arises out of the realities of the commercial market place and the need
to prevent the person with whom the local government is negotiating from sitting in on
the session at which the negotiating terms are developed. (Kleitman v. Superior Court
(1999) 74 Cal.App.4th 324, 331; see also Shapiro v. San Diego City Council (2002)
96 Cal.App.4th 904.)

The closed session, however, must be preceded by an open session in which the body
identifies the real property in question, the individual who will act as its negotiator, and
the persons with whom its negotiator may negotiate. In 73 Ops.Cal.Atty.Gen. 1, 5
(1990), this office concluded that a district interested in purchasing property could not
identify 700 prospective parcels, but must specifically identify the actual parcels
subject to negotiation so that the public would have the opportunity to voice any
objection to the proposed transaction. Eminent domain proceedings are not subject to
section 54956.8, and a body may hold closed sessions to discuss eminent domain
proceedings with its attorney under the pending litigation exception.

Depending on the circumstances, the agency may designate a member of the body, a
staff person, the agency’s attorney or another person to serve as its negotiator.

D. Labor Negotiations Exception

The Act provides for closed sessions to enable a legislative body to meet with its
negotiator concerning discussions with employee organizations and unrepresented
employees regarding salaries and fringe benefits. (§ 54957.6(a).) However, prior to
the closed session, the body must meet in open session and identify its negotiators. The
purpose of the closed session is to permit the body to review its position and instruct
its negotiator concerning the conduct of labor negotiations with current or prospective
employees. During the closed session, the legislative body may approve an agreement
concluding labor negotiations with its represented employees. (See § 54957.1(a)(6).)
However, closed sessions with the negotiator may not include final action on the
proposed compensation of one or more unrepresented employees.

The scope of the closed session held with the negotiator pursuant to section 54957.6
is limited to issues concerning salaries, salary schedules, and compensation paid in the
form of fringe benefits. In addition, for represented employees, the legislative body
also may grant authority to its negotiator concerning any other matter within the
statutorily-provided scope of representation. Closed session discussions under the
labor negotiations exception may include consideration of an agency’s available funds
and funding priorities, so long as such discussions relate to providing instructions to
the local agency’s designated negotiator. It should be emphasized that the labor
negotiations exception applies only to actual bona fide labor negotiations, and a closed
session may not be conducted where a legislative body merely wishes to set the salary
of an employee.
The body may appoint from its membership one or more members constituting less than a quorum, to act as its negotiator, with whom it may meet and confer in closed session under the provisions of section 54957.6. (57 Ops.Cal.Atty.Gen. 209, 212 (1974).) However, if a body decides to conduct its meet-and-confer sessions itself without using a negotiator, the legislative body may not meet in closed session to review and decide upon its bargaining position. (57 Ops.Cal.Atty.Gen. 209, 212 (1974).) In addition, the legislative body as a whole may meet in closed session with a state conciliator who has intervened in the negotiations. (§ 54957.6(a); see also, 51 Ops.Cal.Atty.Gen. 201 (1968).)

For purposes of section 54957.6, the term “employee” not only refers to rank and file, but also includes an officer or an independent contractor who functions as an officer or employee. The term “employee” does not include any elected official, member of a legislative body, or other independent contractors. (§ 54957.6(b).)

E. Public Security Exception

The Act permits local agencies to meet in closed session with the Attorney General, district attorney, agency counsel, sheriff, or chief of police or their deputies, or a security consultant or a security operations manager on matters posing a threat to the security of public buildings, a threat to the security of essential public services, including water, drinking water, wastewater treatment, natural gas service, and electric service, or a threat to the public’s right of access to public services or public facilities. (§ 54957.)

F. License Application Exception

The Act establishes special provisions for the consideration of license applications by persons with criminal records. (§ 54956.7.)

3. Minute Book

The Act provides for the discretionary keeping of a minute book with respect to closed sessions. (§ 54957.2.) The minute book is confidential and shall be available only to members of the legislative body or to a court in connection with litigation involving an alleged violation of the Act during a closed session. (§ 54957.2.) Neither the minute book nor the information which it memorializes may be released by the body’s members. (Cal.Atty.Gen., Indexed Letter, No. IL 76-201 (October 20, 1976).) However, the minutes of an improper closed session are not confidential. (Register Div. of Freedom Newspapers, Inc. v. County of Orange (1984) 158 Cal.App.3d 893, 907-908.)
Under the Act, the recording of closed sessions is authorized by section 54957.2 only to the extent that such recording is accomplished with the knowledge or consent of the other participants in the closed session, pursuant to the requirements of Penal Code section 632. (62 Ops.Cal. Atty. Gen. 292 (1979).)

CHAPTER VII.

PENALTIES AND REMEDIES FOR VIOLATION OF THE ACT

If a person or member of the media believes a violation of open meeting laws has occurred or is about to occur, he or she may wish to contact the local body, the attorney for that body, a superior agency or the district attorney. If such contacts are not successful in resolving the concerns, the complainant may wish to consider one of the remedies or penalties provided by the Legislature to combat violations of the Act. These include criminal penalties, civil injunctive relief and the award of attorney’s fees. In addition, with certain statutory exceptions, actions taken in violation of the Brown Act may be declared null and void by a court.

1. **Criminal Penalties**

The Act provides criminal misdemeanor penalties for certain violations. Specifically, the Act punishes attendance by a member of a body at a meeting where action is taken in violation of the Act, and where the member intends to deprive the public of information to which the member knows or has reason to know the public is entitled. (§ 54959.) The term “action taken” as defined by section 54952.6 includes a collective decision, commitment or promise by a majority of the members of a body. The fact that the decision is tentative rather than final does not shield participants from criminal liability; whether “action” within the meaning of the statute was taken would be a factual question in each case. (61 Ops.Cal. Atty. Gen. 283, 292-293 (1978).) Mere deliberation without the taking of some action will not trigger a criminal penalty.

2. **Civil Remedies**

A. **Injunctive, Mandatory or Declaratory Relief**

The Act provides two distinct types of civil remedies:

(1) Injunction, mandamus or declaratory relief to prevent or stop violations or threatened violations. (§ 54960.)

(2) Action to void past acts of the body. (§ 54960.1.)
These remedies are discussed in turn below.

The district attorney or any interested person also may seek injunctive, mandatory or declaratory relief in a superior court. (§ 54960.) An “interested person” may include, in addition to the public, a public entity or its officers. Unlike the criminal remedy, these civil remedies do not require that the body take action or that the members act with a specific intent to deprive the public of information to which the members know that the public is entitled.

In granting complainants the power to seek injunctive, mandatory or declaratory relief, the Legislature indicated on the face of the statute that such remedies were available to stop or prevent violations of the Act. (§ 54960.) This point was reiterated by the California Supreme Court in the case of Regents of the University of California v. Superior Court (1999) 20 Cal.4th 509, 522, where it concluded that these remedies were not available to redress the past actions of a body. However, with respect to state agencies, the Legislature quickly acted to supersede this interpretation. (See § 11130.)

A body may not always announce its intended action so as to give rise to an action for injunctive, mandatory or declaratory relief. Under these circumstances, the plaintiff may seek to support its case by demonstrating that a pattern of past conduct indicates the existence of present or future violations. (Shapiro v. San Diego City Council (2002) 96 Cal.App.4th 904; Duval v. Board of Trustees (2001) 93 Cal.App.4th 902, 906.) Alternatively, the body may seek to demonstrate that there is a current controversy that is evidenced by past practices of the body, and the body has not renounced such practices. (CAUSE v. City of San Diego (1997) 56 Cal.App.4th 1024, 1029.) The court indicated that since the city would not admit to a violation it was likely that the current practices would continue. The court in Common Cause v. Stirling (1983) 147 Cal.App.3d 518, 524, concluded that courts may presume that a municipality will continue similar practices in light of the city attorney’s refusal to admit the violation.

Where a legislative body has committed a violation of the Act concerning the conduct of closed sessions subject to the Act, a court may order the body to tape record future closed sessions pursuant to the procedures set forth in section 54960(b).

B. Voidability of Action

Either interested persons or the district attorney may seek to have actions taken in violation of the Act declared null and void by a court. (§ 54960.1.) In Boyle v. City of Redondo Beach (1999) 70 Cal.App.4th 1109, 1118, the court ruled that merely conferring with and giving direction to staff, where no vote was taken and no decision made, did not constitute action that could be adjudged null and void.
The Act specifically provides that before a suit can be initiated, the complainant must make within 90 days a written demand to the board to cure or correct the violation, unless the action was taken in an open session but in violation of section 54954.2 (agenda requirements), in which case the written demand shall be made within 30 days from the date the action was taken. (§ 54960.1(c)(1); County of Del Norte v. City of Crescent City (1999) 71 Cal.App.4th 965, 978; Bell v. Vista Unified School Dist. (2000) 82 Cal.App.4th 672, 684.) The Act further provides that if the board refuses or fails to cure or correct a violation of sections 54953, 54954.2, 54954.5, 54954.6, 54956 or 54956.5 within 30 days from receipt of the written demand, the complainant may file a suit to have the action adjudged null and void. (§ 54960.1(c)(3).) Suits under this section must be brought within 15 days after receipt of the body’s decision to cure or correct, or not to cure or correct; or 15 days after the expiration of the 30-day period for the body to cure or correct -- whichever is earlier. (§ 54960.1(c)(4); see Boyle v. City of Redondo Beach (1999) 70 Cal.App.4th 1109, 1117, fn. 5.) Once an action is challenged, a body nevertheless may cure or correct that action without prejudice and, where a lawsuit has been filed, may have the suit dismissed. (§ 54960.1(e); see Boyle v. City of Redondo Beach (1999) 70 Cal.App.4th 1109; Bell v. Vista Unified School Dist. (2000) 82 Cal.App.4th 672, 685.) Since a violation may be cured or corrected after a lawsuit has been filed, the plaintiff need not wait for an answer to its demand that a body cure or correct an action before filing suit. (See Bell v. Vista Unified School Dist. (2000) 82 Cal.App.4th 672 [where the demand and the lawsuit were filed on the same day].)

Exemptions are provided in connection with decisions involving bonds, taxes and contracts on which there has been detrimental reliance. (§ 54960.1(d).) Also, actions “in substantial compliance” with the requirements of the Brown Act are exempt. (§ 54960.1(d)(1); see County of Del Norte v. City of Crescent City (1999) 71 Cal.App.4th 965, 978-979.) Persons having actual notice of matters to be considered at a meeting, within statutorily prescribed time periods in advance of a meeting, are barred from suing to have an action declared null and void. (§ 54960.1(d)(5).)

In a case concerning a similar provision of the open meeting law governing state agencies, the California Supreme Court found that the time deadlines for notification and initiation of a legal action could not be extended, even if the defendant fraudulently concealed violations of the open meeting law. The Court concluded that the time deadlines were intended to balance two conflicting policies: the desire to permit nullification of an agency’s decisions on the one hand, and the need not to imperil the finality of agency decisions, on the other. Extension of the time deadlines would disturb this balance. (Regents of the University of California v. Superior Court (1999) 20 Cal.4th 509, 527.)

For a summary of the foregoing time deadlines for filing a suit to void an action taken by a body see Appendix A.
C. Attorney Fees

The Act provides for the award of attorney fees. (§ 54960.5.)

The Act provides that a plaintiff may receive attorney fees, but the award is against the agency, not the individual member or members who violated the Act. The defendant agency also may receive attorney fees when it prevails in a final determination and when the proceeding against the agency is frivolous and without merit. (Sutter Sensible Planning, Inc. v. Board of Supervisors (1981) 122 Cal.App.3d 813, 825-826; Frazer v. Dixon Unified School Dist. (1993) 18 Cal.App.4th 781, 800.)

The provision authorizing the award of attorney fees and court costs applies to both trial court and appellate court litigation. (Boyle v. City of Redondo Beach (1999) 70 Cal.App.4th 1109, 1121-1122; International Longshoremen’s & Warehousemen’s Union v. Los Angeles Expert Terminal, Inc. (1999) 69 Cal.App.4th 287, 302-304.) However, the award of fees is in the nature of a sanction and therefore, due process must be observed in the making of the award. Accordingly, the court must make written findings in order for a reviewing court to determine whether the awarding court properly exercised its discretion. (Boyle v. City of Redondo Beach (1999) 70 Cal.App.4th 1109.)

In Common Cause v. Stirling (1981) 119 Cal.App.3d 658, the trial court measured the petition for attorney fees under section 54960.5 against the standards established in Code of Civil Procedure section 1021.5, regarding the enforcement of an important right affecting the public interest.

Since the trial court concluded that attorney fees would not have been justified under section 1021.5, it refused to grant an award under the Act. The appellate court reversed, stating that even though recoveries would be small under normal principles, the damage was to the public integrity and, therefore, the Legislature had determined that public funds should be made available to pay for attorney fees to enforce these laws. Factors which should be considered in determining whether an award of attorney fees would be “unjust” and, therefore, should not be made, include the effect of such an award on settlement, the necessity for the lawsuit, the lack of injury to the public, the likelihood that the problem would have been solved by other means, and the likelihood that the problem would reoccur in the absence of the lawsuit.

The case was remanded to the trial court which still concluded that the plaintiff was not entitled to attorney fees. The matter once again was appealed, and the appellate court reversed the trial court a second time. (Common Cause v. Stirling (1983) 147 Cal.App.3d 518.) The court held that the plaintiff was entitled to attorney fees because it had established a legal principle on behalf of the public.
In *International Longshoremen’s & Warehousemen’s Union v. Los Angeles Expert Terminal, Inc.* (1999) 69 Cal.App.4th 287, 302, the court upheld an award of attorney fees because without the suit, violations of the Brown Act would have been ongoing. There, a for profit corporation claimed that it was not subject to the Brown Act. Plaintiffs demonstrated that the Act was applicable because the entity was created by a city council in order to exercise delegated governmental authority.

The award of fees may reflect market rates even though the prevailing party’s attorney fees were lower. (*International Longshoremen’s & Warehousemen’s Union v. Los Angeles Expert Terminal, Inc.* (1999) 69 Cal.App.4th 287, 303.)
APPENDIX A

TIME DEADLINES

FOR FILING A SUIT TO VOID AN ACTION TAKEN BY A BODY

An action is taken that a district attorney or interested person believes is in violation of:

- general open meeting requirement (§ 54953)
- agenda requirements for regular meetings (§ 54954.2)
- safe harbor notice provisions for closed sessions (§ 54954.5)
- procedures for new taxes and assessments (§ 54954.6)
- requirements for special meetings (§ 54956)
- requirements for emergency meetings (§ 54956.5)

Complainant must make written demand to the body to cure or correct within:

A. 30 days of the action if it were in open session, but in violation of agenda requirements.

B. 90 days of the action in all other situations.

Once the body receives demand, it has 30 days to cure or correct the violation.

If the body fails to cure or correct within this 30-day period, interested person may file suit to void the action.

The action must be filed within 15 days of:

A. Receipt of decision to cure or correct or refusal to do so.

B. End of 30-day period to cure or correct.
APPENDIX B

THE RALPH M. BROWN ACT

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§ 54950. Policy declaration

In enacting this chapter, the Legislature finds and declares that the public commissions, boards and councils and the other public agencies in this State exist to aid in the conduct of the people’s business. It is the intent of the law that their actions be taken openly and that their deliberations be conducted openly.

The people of this State do not yield their sovereignty to the agencies which serve them. The people, in delegating authority, do not give their public servants the right to decide what is good for the people to know and what is not good for them to know. The people insist on remaining informed so that they may retain control over the instruments they have created.

§ 54950.5. Title

This chapter shall be known as the Ralph M. Brown Act.

§ 54951. Definition of local agency

As used in this chapter, “local agency” means a county, city, whether general law or chartered, city and county, town, school district, municipal corporation, district, political subdivision, or any board, commission or agency thereof, or other local public agency.
Definition of legislative body

As used in this chapter, “legislative body” means:

(a) The governing body of a local agency or any other local body created by state or federal statute.

(b) A commission, committee, board, or other body of a local agency, whether permanent or temporary, decisionmaking or advisory, created by charter, ordinance, resolution, or formal action of a legislative body. However, advisory committees, composed solely of the members of the legislative body that are less than a quorum of the legislative body are not legislative bodies, except that standing committees of a legislative body, irrespective of their composition, which have a continuing subject matter jurisdiction, or a meeting schedule fixed by charter, ordinance, resolution, or formal action of a legislative body are legislative bodies for purposes of this chapter.

(c) (1) A board, commission, committee, or other multimember body that governs a private corporation, limited liability company, or other entity that either:

   (A) Is created by the elected legislative body in order to exercise authority that may lawfully be delegated by the elected governing body to a private corporation, limited liability company, or other entity.

   (B) Receives funds from a local agency and the membership of whose governing body includes a member of the legislative body of the local agency appointed to that governing body as a full voting member by the legislative body of the local agency.

(2) Notwithstanding subparagraph (B) of paragraph (1), no board, commission, committee, or other multimember body that governs a private corporation, limited liability company, or other entity that receives funds from a local agency and, as of February 9, 1996, has a member of the legislative body of the local agency as a full voting member of the governing body of that private corporation, limited liability company, or other entity shall be relieved from the public meeting requirements of this chapter by virtue of a change in status of the full voting member to a nonvoting member.

(d) The lessee of any hospital the whole or part of which is first leased pursuant to subdivision (p) of Section 32121 of the Health and Safety Code after January 1, 1994, where the lessee exercises any material authority of a legislative body of a local agency delegated to it by that legislative body whether the lessee is organized and operated by the local agency or by a delegated authority.
54952.1. Definition of member of a legislative body

Any person elected to serve as a member of a legislative body who has not yet assumed the duties of office shall conform his or her conduct to the requirements of this chapter and shall be treated for purposes of enforcement of this chapter as if he or she has already assumed office.

54952.2. Definition of meeting

(a) As used in this chapter, “meeting” includes any congregation of a majority of the members of a legislative body at the same time and place to hear, discuss, or deliberate upon any item that is within the subject matter jurisdiction of the legislative body or the local agency to which it pertains.

(b) Except as authorized pursuant to Section 54953, any use of direct communication, personal intermediaries, or technological devices that is employed by a majority of the members of the legislative body to develop a collective concurrence as to action to be taken on an item by the members of the legislative body is prohibited.

(c) Nothing in this section shall impose the requirements of this chapter upon any of the following:

(1) Individual contacts or conversations between a member of a legislative body and any other person.

(2) The attendance of a majority of the members of a legislative body at a conference or similar gathering open to the public that involves a discussion of issues of general interest to the public or to public agencies of the type represented by the legislative body, provided that a majority of the members do not discuss among themselves, other than as part of the scheduled program, business of a specified nature that is within the subject matter jurisdiction of the local agency. Nothing in this paragraph is intended to allow members of the public free admission to a conference or similar gathering at which the organizers have required other participants or registrants to pay fees or charges as a condition of attendance.

(3) The attendance of a majority of the members of a legislative body at an open and publicized meeting organized to address a topic of local community concern by a person or organization other than the local agency, provided that a majority of the members do not discuss among themselves, other than as part of the scheduled program, business of a specific nature that is within the subject matter jurisdiction of the legislative body of the local agency.

(4) The attendance of a majority of the members of a legislative body at an open and noticed meeting of another body of the local agency, or at an open and noticed meeting of a legislative body of another local agency, provided that a majority of the members do not discuss among
themselves, other than as part of the scheduled meeting, business of a specific nature that is within the subject matter jurisdiction of the legislative body of the local agency.

(5) The attendance of a majority of the members of a legislative body at a purely social or ceremonial occasion, provided that a majority of the members do not discuss among themselves business of a specific nature that is within the subject matter jurisdiction of the legislative body of the local agency.

(6) The attendance of a majority of the members of a legislative body at an open and noticed meeting of a standing committee of that body, provided that the members of the legislative body who are not members of the standing committee attend only as observers.

54952.6. Definition of action taken

As used in this chapter, “action taken” means a collective decision made by a majority of the members of a legislative body, a collective commitment or promise by a majority of the members of a legislative body to make a positive or a negative decision, or an actual vote by a majority of the members of a legislative body when sitting as a body or entity, upon a motion, proposal, resolution, order or ordinance.

54952.7. Copies of Act; Distribution

A legislative body of a local agency may require that a copy of this chapter be given to each member of the legislative body and any person elected to serve as a member of the legislative body who has not assumed the duties of office. An elected legislative body of a local agency may require that a copy of this chapter be given to each member of each legislative body all or a majority of whose members are appointed by or under the authority of the elected legislative body.

54953. Open meetings required; Teleconferencing; Secret ballots

(a) All meetings of the legislative body of a local agency shall be open and public, and all persons shall be permitted to attend any meeting of the legislative body of a local agency, except as otherwise provided in this chapter.

(b) (1) Notwithstanding any other provision of law, the legislative body of a local agency may use teleconferencing for the benefit of the public and the legislative body of a local agency in connection with any meeting or proceeding authorized by law. The teleconferenced meeting or proceeding shall comply with all requirements of this chapter and all otherwise applicable provisions of law relating to a specific type of meeting or proceeding.

(2) Teleconferencing, as authorized by this section, may be used for all purposes in connection with any meeting within the subject matter jurisdiction of the legislative body. All votes taken during a teleconferenced meeting shall be by rollcall.
(3) If the legislative body of a local agency elects to use teleconferencing, it shall post agendas at all teleconference locations and conduct teleconference meetings in a manner that protects the statutory and constitutional rights of the parties or the public appearing before the legislative body of a local agency. Each teleconference location shall be identified in the notice and agenda of the meeting or proceeding, and each teleconference location shall be accessible to the public. During the teleconference, at least a quorum of the members of the legislative body shall participate from locations within the boundaries of the territory over which the local agency exercises jurisdiction. The agenda shall provide an opportunity for members of the public to address the legislative body directly pursuant to Section 54954.3 at each teleconference location.

(4) For the purposes of this section, “teleconference” means a meeting of a legislative body, the members of which are in different locations, connected by electronic means, through either audio or video, or both. Nothing in this section shall prohibit a local agency from providing the public with additional teleconference locations.

(c) No legislative body shall take action by secret ballot, whether preliminary or final.

54953.2. Meeting; Disability rights

All meetings of a legislative body of a local agency that are open and public shall meet the protections and prohibitions contained in Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof.

54953.1. Grand jury testimony by members

The provisions of this chapter shall not be construed to prohibit the members of the legislative body of a local agency from giving testimony in private before a grand jury, either as individuals or as a body.

54953.3. Conditions to attendance at meetings

A member of the public shall not be required, as a condition to attendance at a meeting of a legislative body of a local agency, to register his or her name, to provide other information, to complete a questionnaire, or otherwise to fulfill any condition precedent to his or her attendance.

If an attendance list, register, questionnaire, or other similar document is posted at or near the entrance to the room where the meeting is to be held, or is circulated to the persons present during the meeting, it shall state clearly that the signing, registering, or completion of the document is voluntary, and that all persons may attend the meeting regardless of whether a person signs, registers, or completes the document.
54953.5. Recording meetings

(a) Any person attending an open and public meeting of a legislative body of a local agency shall have the right to record the proceedings with an audio or video tape recorder or a still or motion picture camera in the absence of a reasonable finding by the legislative body of the local agency that the recording cannot continue without noise, illumination, or obstruction of view that constitutes, or would constitute, a persistent disruption of the proceedings.

(b) Any tape or film record of an open and public meeting made for whatever purpose by or at the direction of the local agency shall be subject to inspection pursuant to the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), but, notwithstanding Section 34090, may be erased or destroyed 30 days after the taping or recording. Any inspection of a video or tape recording shall be provided without charge on a video or tape player made available by the local agency.

54953.6. Broadcasting meetings

No legislative body of a local agency shall prohibit or otherwise restrict the broadcast of its open and public meetings in the absence of a reasonable finding that the broadcast cannot be accomplished without noise, illumination, or obstruction of view that would constitute a persistent disruption of the proceedings.

54953.7. Greater access to meetings permitted

Notwithstanding any other provision of law, legislative bodies of local agencies may impose requirements upon themselves which allow greater access to their meetings than prescribed by the minimal standards set forth in this chapter. In addition thereto, an elected legislative body of a local agency may impose such requirements on those appointed legislative bodies of the local agency of which all or a majority of the members are appointed by or under the authority of the elected legislative body.

54954. Notice of regular meetings; Boundary restrictions for all meetings

(a) Each legislative body of a local agency, except for advisory committees or standing committees, shall provide, by ordinance, resolution, bylaws, or by whatever other rule is required for the conduct of business by that body, the time and place for holding regular meetings. Meetings of advisory committees or standing committees, for which an agenda is posted at least 72 hours in advance of the meeting pursuant to subdivision (a) of Section 54954.2, shall be considered for purposes of this chapter as regular meetings of the legislative body.

(b) Regular and special meetings of the legislative body shall be held within the boundaries of the territory over which the local agency exercises jurisdiction, except to do any of the following:
(1) Comply with state or federal law or court order, or attend a judicial or administrative proceeding to which the local agency is a party.

(2) Inspect real or personal property which cannot be conveniently brought within the boundaries of the territory over which the local agency exercises jurisdiction provided that the topic of the meeting is limited to items directly related to the real or personal property.

(3) Participate in meetings or discussions of multiagency significance that are outside the boundaries of a local agency’s jurisdiction. However, any meeting or discussion held pursuant to this subdivision shall take place within the jurisdiction of one of the participating local agencies and be noticed by all participating agencies as provided for in this chapter.

(4) Meet in the closest meeting facility if the local agency has no meeting facility within the boundaries of the territory over which the local agency exercises jurisdiction, or at the principal office of the local agency if that office is located outside the territory over which the agency exercises jurisdiction.

(5) Meet outside their immediate jurisdiction with elected or appointed officials of the United States or the State of California when a local meeting would be impractical, solely to discuss a legislative or regulatory issue affecting the local agency and over which the federal or state officials have jurisdiction.

(6) Meet outside their immediate jurisdiction if the meeting takes place in or nearby a facility owned by the agency, provided that the topic of the meeting is limited to items directly related to the facility.

(7) Visit the office of the local agency’s legal counsel for a closed session on pending litigation held pursuant to Section 54956.9, when to do so would reduce legal fees or costs.

(c) Meetings of the governing board of a school district shall be held within the district except under the circumstances enumerated in subdivision (b), or to do any of the following:

(1) Attend a conference on nonadversarial collective bargaining techniques.

(2) Interview members of the public residing in another district with reference to the trustees’ potential employment of the superintendent of that district.

(3) Interview a potential employee from another district.

(d) Meetings of a joint powers authority shall occur within the territory of at least one of its member agencies, or as provided in subdivision (b). However, a joint powers authority which has members throughout the state may meet at any facility in the state which complies with the requirements of Section 54961.
(e) If, by reason of fire, flood, earthquake, or other emergency, it shall be unsafe to meet in the place designated, the meetings shall be held for the duration of the emergency at the place designated by the presiding officer of the legislative body or his or her designee in a notice to the local media that have requested notice pursuant to Section 54956, by the most rapid means of communication available at the time.

54954.1. Agenda information provided by mail; Fee

Any person may request that a copy of the agenda, or a copy of all the documents constituting the agenda packet, of any meeting of a legislative body be mailed to that person. If requested, the agenda and documents in the agenda packet shall be made available in appropriate alternative formats to persons with a disability, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof. Upon receipt of the written request, the legislative body or its designee shall cause the requested materials to be mailed at the time the agenda is posted pursuant to Section 54954.2 and 54956 or upon distribution to all, or a majority of all, of the members of a legislative body, whichever occurs first. Any request for mailed copies of agendas or agenda packets shall be valid for the calendar year in which it is filed, and must be renewed following January 1 of each year. The legislative body may establish a fee for mailing the agenda or agenda packet, which fee shall not exceed the cost of providing the service. Failure of the requesting person to receive the agenda or agenda packet pursuant to this section shall not constitute grounds for invalidation of the actions of the legislative body taken at the meeting for which the agenda or agenda packet was not received.

54954.2. Agenda requirements; Regular meetings

(a) At least 72 hours before a regular meeting, the legislative body of the local agency, or its designee, shall post an agenda containing a brief general description of each item of business to be transacted or discussed at the meeting, including items to be discussed in closed session. A brief general description of an item generally need not exceed 20 words. The agenda shall specify the time and location of the regular meeting and shall be posted in a location that is freely accessible to members of the public. If requested, the agenda shall be made available in appropriate alternative formats to persons with a disability, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof. The agenda shall include information regarding how, to whom, and when a request for disability-related modification or accommodation, including auxiliary aids or services may be made by a person with a disability who requires a modification or accommodation in order to participate in the public meeting.

No action or discussion shall be undertaken on any item not appearing on the posted agenda, except that members of a legislative body or its staff may briefly respond to statements made or questions posed by persons exercising their public testimony rights under Section 54954.3. In addition, on their own initiative or in response to questions posed by the public, a member of a legislative body or its staff may ask a question for clarification, make a brief announcement, or make a brief report on
his or her own activities. Furthermore, a member of a legislative body, or the body itself, subject to
rules or procedures of the legislative body, may provide a reference to staff or other resources for
factual information, request staff to report back to the body at a subsequent meeting concerning any
matter, or take action to direct staff to place a matter of business on a future agenda.

(b) Notwithstanding subdivision (a), the legislative body may take action on items of
business not appearing on the posted agenda under any of the conditions stated below. Prior to
discussing any item pursuant to this subdivision, the legislative body shall publicly identify the item.

(1) Upon a determination by a majority vote of the legislative body that an
emergency situation exists, as defined in Section 54956.5.

(2) Upon a determination by a two-thirds vote of the members of the legislative
body present at the meeting, or, if less than two-thirds of the members are present, a unanimous vote
of those members present, that there is a need to take immediate action and that the need for action
came to the attention of the local agency subsequent to the agenda being posted as specified in
subdivision (a).

(3) The item was posted pursuant to subdivision (a) for a prior meeting of the
legislative body occurring not more than five calendar days prior to the date action is taken on the item,
and at the prior meeting the item was continued to the meeting at which action is being taken.

54954.3. Public’s right to testify at meetings

(a) Every agenda for regular meetings shall provide an opportunity for members of the
public to directly address the legislative body on any item of interest to the public, before or during
the legislative body’s consideration of the item, that is within the subject matter jurisdiction of the
legislative body, provided that no action shall be taken on any item not appearing on the agenda unless
the action is otherwise authorized by subdivision (b) of Section 54954.2. However, the agenda need
not provide an opportunity for members of the public to address the legislative body on any item that
has already been considered by a committee, composed exclusively of members of the legislative body,
at a public meeting wherein all interested members of the public were afforded the opportunity to
address the committee on the item, before or during the committee’s consideration of the item, unless
the item has been substantially changed since the committee heard the item, as determined by the
legislative body. Every notice for a special meeting shall provide an opportunity for members of the
public to directly address the legislative body concerning any item that has been described in the notice
for the meeting before or during consideration of that item.

(b) The legislative body of a local agency may adopt reasonable regulations to ensure that
the intent of subdivision (a) is carried out, including, but not limited to, regulations limiting the total
amount of time allocated for public testimony on particular issues and for each individual speaker.
(c) The legislative body of a local agency shall not prohibit public criticism of the policies, procedures, programs, or services of the agency, or of the acts or omissions of the legislative body. Nothing in this subdivision shall confer any privilege or protection for expression beyond that otherwise provided by law.

54954.4. Reimbursement of costs

(a) The Legislature hereby finds and declares that Section 12 of Chapter 641 of the Statutes of 1986, authorizing reimbursement to local agencies and school districts for costs mandated by the state pursuant to that act, shall be interpreted strictly. The intent of the Legislature is to provide reimbursement for only those costs which are clearly and unequivocally incurred as the direct and necessary result of compliance with Chapter 641 of the Statutes of 1986.

(b) In this regard, the Legislature directs all state employees and officials involved in reviewing or authorizing claims for reimbursement, or otherwise participating in the reimbursement process, to rigorously review each claim and authorize only those claims, or parts thereof, which represent costs which are clearly and unequivocally incurred as the direct and necessary result of compliance with Chapter 641 of the Statutes of 1986 and for which complete documentation exists. For purposes of Section 54954.2, costs eligible for reimbursement shall only include the actual cost to post a single agenda for any one meeting.

(c) The Legislature hereby finds and declares that complete, faithful, and uninterrupted compliance with the Ralph M. Brown Act (Chapter 9 (commencing with Section 54950) of Part 1 of Division 2 of Title 5 of the Government Code) is a matter of overriding public importance. Unless specifically stated, no future Budget Act, or related budget enactments, shall, in any manner, be interpreted to suspend, eliminate, or otherwise modify the legal obligation and duty of local agencies to fully comply with Chapter 641 of the Statutes of 1986 in a complete, faithful, and uninterrupted manner.

54954.5. Safe harbor agenda for closed sessions

For purposes of describing closed session items pursuant to Section 54954.2, the agenda may describe closed sessions as provided below. No legislative body or elected official shall be in violation of Section 54954.2 or 54956 if the closed session items were described in substantial compliance with this section. Substantial compliance is satisfied by including the information provided below, irrespective of its format.

(a) With respect to a closed session held pursuant to Section 54956.7:

LICENSE/PERMIT DETERMINATION

Applicant(s): (Specify number of applicants)
(b) With respect to every item of business to be discussed in closed session pursuant to Section 54956.8:

CONFERENCE WITH REAL PROPERTY NEGOTIATORS

Property: (Specify street address, or if no street address, the parcel number or other unique reference, of the real property under negotiation)

Agency negotiator: (Specify names of negotiators attending the closed session) (If circumstances necessitate the absence of a specified negotiator, an agent or designee may participate in place of the absent negotiator so long as the name of the agent or designee is announced at an open session held prior to the closed session.)

Negotiating parties: (Specify name of party (not agent))

Under negotiation: (Specify whether instruction to negotiator will concern price, terms of payment, or both)

(c) With respect to every item of business to be discussed in closed session pursuant to Section 54956.9:

CONFERENCE WITH LEGAL COUNSEL--EXISTING LITIGATION
(Subdivision (a) of Section 54956.9)

Name of case: (Specify by reference to claimant's name, names of parties, case or claim numbers)

or

Case name unspecified: (Specify whether disclosure would jeopardize service of process or existing settlement negotiations)

CONFERENCE WITH LEGAL COUNSEL--ANTICIPATED LITIGATION

Significant exposure to litigation pursuant to subdivision (b) of Section 54956.9: (Specify number of potential cases)

(In addition to the information noticed above, the agency may be required to provide additional information on the agenda or in an oral statement prior to the closed session pursuant to subparagraphs (B) to (E), inclusive, of paragraph (3) of subdivision (b) of Section 54956.9.)
Initiation of litigation pursuant to subdivision (c) of Section 54956.9: (Specify number of potential cases)

(d) With respect to every item of business to be discussed in closed session pursuant to Section 54956.95:

LIABILITY CLAIMS

Claimant: (Specify name unless unspecified pursuant to Section 54961)

Agency claimed against: (Specify name)

(e) With respect to every item of business to be discussed in closed session pursuant to Section 54957:

THREAT TO PUBLIC SERVICES OR FACILITIES

Consultation with: (Specify name of law enforcement agency and title of officer, or name of applicable agency representative and title)

PUBLIC EMPLOYEE APPOINTMENT

Title: (Specify description of position to be filled)

PUBLIC EMPLOYMENT

Title: (Specify description of position to be filled)

PUBLIC EMPLOYEE PERFORMANCE EVALUATION

Title: (Specify position title of employee being reviewed)

PUBLIC EMPLOYEE DISCIPLINE/DISMISSAL/RELEASE

(No additional information is required in connection with a closed session to consider discipline, dismissal, or release of a public employee. Discipline includes potential reduction of compensation.)

(f) With respect to every item of business to be discussed in closed session pursuant to Section 54957.6:
CONFERENCES WITH LABOR NEGOTIATORS

Agency designated representatives: (Specify names of designated representatives attending the closed session) (If circumstances necessitate the absence of a specified designated representative, an agent or designee may participate in place of the absent representative so long as the name of the agent or designee is announced at an open session held prior to the closed session.)

Employee organization: (Specify name of organization representing employee or employees in question)

or

Unrepresented employee: (Specify position title of unrepresented employee who is the subject of the negotiations)

(g) With respect to closed sessions called pursuant to Section 54957.8:

CASE REVIEW/PLANNING

(No additional information is required in connection with a closed session to consider case review or planning.)

(h) With respect to every item of business to be discussed in closed session pursuant to Sections 1461, 32106, and 32155 of the Health and Safety Code or Sections 37606 and 37624.3 of the Government Code:

REPORT INVOLVING TRADE SECRET

Discussion will concern: (Specify whether discussion will concern proposed new service, program, or facility)

Estimated date of public disclosure: (Specify month and year)

HEARINGS

Subject matter: (Specify whether testimony/deliberation will concern staff privileges, report of medical audit committee, or report of quality assurance committee)

(i) With respect to every item of business to be discussed in closed session pursuant to Section 54956.86:
CHARGE OR COMPLAINT INVOLVING INFORMATION PROTECTED BY FEDERAL LAW

(No additional information is required in connection with a closed session to discuss a charge or complaint pursuant to Section 54956.86.)

54954.6. New taxes and/or assessments; Procedural requirements

(a) (1) Before adopting any new or increased general tax or any new or increased assessment, the legislative body of a local agency shall conduct at least one public meeting at which local officials shall allow public testimony regarding the proposed new or increased general tax or new or increased assessment in addition to the noticed public hearing at which the legislative body proposes to enact or increase the general tax or assessment.

For purposes of this section, the term “new or increased assessment” does not include any of the following:

(A) A fee that does not exceed the reasonable cost of providing the services, facilities, or regulatory activity for which the fee is charged.

(B) A service charge, rate, or charge, unless a special district’s principal act requires the service charge, rate, or charge to conform to the requirements of this section.

(C) An ongoing annual assessment if it is imposed at the same or lower amount as any previous year.

(D) An assessment that does not exceed an assessment formula or range of assessments previously specified in the notice given to the public pursuant to subparagraph (G) of paragraph (2) of subdivision (c) and that was previously adopted by the agency or approved by the voters in the area where the assessment is imposed.

(E) Standby or immediate availability charges.

(2) The legislative body shall provide at least 45 days’ public notice of the public hearing at which the legislative body proposes to enact or increase the general tax or assessment. The legislative body shall provide notice for the public meeting at the same time and in the same document as the notice for the public hearing, but the meeting shall occur prior to the hearing.

(b) (1) The joint notice of both the public meeting and the public hearing required by subdivision (a) with respect to a proposal for a new or increased general tax shall be accomplished by placing a display advertisement of at least one-eighth page in a newspaper of general circulation for three weeks pursuant to Section 6063 and by a first-class mailing to those interested parties who have filed a written request with the local agency for mailed notice of public meetings or hearings on new
or increased general taxes. The public meeting pursuant to subdivision (a) shall take place no earlier than 10 days after the first publication of the joint notice pursuant to this subdivision. The public hearing shall take place no earlier than seven days after the public meeting pursuant to this subdivision. Notwithstanding paragraph (2) of subdivision (a), the joint notice need not include notice of the public meeting after the meeting has taken place. The public hearing pursuant to subdivision (a) shall take place no earlier than 45 days after the first publication of the joint notice pursuant to this subdivision. Any written request for mailed notices shall be effective for one year from the date on which it is filed unless a renewal request is filed. Renewal requests for mailed notices shall be filed on or before April 1 of each year. The legislative body may establish a reasonable annual charge for sending notices based on the estimated cost of providing the service.

(2) The notice required by paragraph (1) of this subdivision shall include, but not be limited to, the following:

(A) The amount or rate of the tax. If the tax is proposed to be increased from any previous year, the joint notice shall separately state both the existing tax rate and the proposed tax rate increase.

(B) The activity to be taxed.

(C) The estimated amount of revenue to be raised by the tax annually.

(D) The method and frequency for collecting the tax.

(E) The dates, times, and locations of the public meeting and hearing described in subdivision (a).

(F) The phone number and address of an individual, office, or organization that interested persons may contact to receive additional information about the tax.

(c) (1) The joint notice of both the public meeting and the public hearing required by subdivision (a) with respect to a proposal for a new or increased assessment on real property shall be accomplished through a mailing, postage prepaid, in the United States mail and shall be deemed given when so deposited. The public meeting pursuant to subdivision (a) shall take place no earlier than 10 days after the joint mailing pursuant to this subdivision. The public hearing shall take place no earlier than seven days after the public meeting pursuant to this subdivision. The envelope or the cover of the mailing shall include the name of the local agency and the return address of the sender. This mailed notice shall be in at least 10-point type and shall be given to all property owners proposed to be subject to the new or increased assessment by a mailing by name to those persons whose names and addresses appear on the last equalized county assessment roll or the State Board of Equalization assessment roll, as the case may be.
(2) The joint notice required by paragraph (1) of this subdivision shall include, but not be limited to, the following:

(A) The estimated amount of the assessment per parcel. If the assessment is proposed to be increased from any previous year, the joint notice shall separately state both the amount of the existing assessment and the proposed assessment increase.

(B) A general description of the purpose or improvements that the assessment will fund.

(C) The address to which property owners may mail a protest against the assessment.

(D) The phone number and address of an individual, office, or organization that interested persons may contact to receive additional information about the assessment.

(E) A statement that a majority protest will cause the assessment to be abandoned if the assessment act used to levy the assessment so provides. Notice shall also state the percentage of protests required to trigger an election, if applicable.

(F) The dates, times, and locations of the public meeting and hearing described in subdivision (a).

(G) A proposed assessment formula or range as described in subparagraph (D) of paragraph (1) of subdivision (a) if applicable and that is noticed pursuant to this section.

(3) Notwithstanding paragraph (1), in the case of an assessment that is proposed exclusively for operation and maintenance expenses imposed throughout the entire local agency, or exclusively for operation and maintenance assessments proposed to be levied on 50,000 parcels or more, notice may be provided pursuant to this subdivision or pursuant to paragraph (1) of subdivision (b) and shall include the estimated amount of the assessment of various types, amounts, or uses of property and the information required by subparagraphs (B) to (G), inclusive, of paragraph (2) of subdivision (c).

(4) Notwithstanding paragraph (1), in the case of an assessment proposed to be levied pursuant to Part 2 (commencing with Section 22500) of Division 2 of the Streets and Highways Code by a regional park district, regional park and open-space district, or regional open-space district formed pursuant to Article 3 (commencing with Section 5500) of Chapter 3 of Division 5 of, or pursuant to Division 26 (commencing with Section 35100) of, the Public Resources Code, notice may be provided pursuant to paragraph (1) of subdivision (b).
(d) The notice requirements imposed by this section shall be construed as additional to, and not to supersede, existing provisions of law, and shall be applied concurrently with the existing provisions so as to not delay or prolong the governmental decisionmaking process.

(e) This section shall not apply to any new or increased general tax or any new or increased assessment that requires an election of either of the following:

1. The property owners subject to the assessment.

2. The voters within the local agency imposing the tax or assessment.

(f) Nothing in this section shall prohibit a local agency from holding a consolidated meeting or hearing at which the legislative body discusses multiple tax or assessment proposals.

(g) The local agency may recover the reasonable costs of public meetings, public hearings, and notice required by this section from the proceeds of the tax or assessment. The costs recovered for these purposes, whether recovered pursuant to this subdivision or any other provision of law, shall not exceed the reasonable costs of the public meetings, public hearings, and notice.

(h) Any new or increased assessment that is subject to the notice and hearing provisions of Article XIIIC or XIIID of the California Constitution is not subject to the notice and hearing requirements of this section.

54955. Adjeournment

The legislative body of a local agency may adjourn any regular, adjourned regular, special or adjourned special meeting to a time and place specified in the order of adjournment. Less than a quorum may so adjourn from time to time. If all members are absent from any regular or adjourned regular meeting the clerk or secretary of the legislative body may declare the meeting adjourned to a stated time and place and he shall cause a written notice of the adjournment to be given in the same manner as provided in Section 54956 for special meetings, unless such notice is waived as provided for special meetings. A copy of the order or notice of adjournment shall be conspicuously posted on or near the door of the place where the regular, adjourned regular, special or adjourned special meeting was held within 24 hours after the time of the adjournment. When a regular or adjourned regular meeting is adjourned as provided in this section, the resulting adjourned regular meeting is a regular meeting for all purposes. When an order of adjournment of any meeting fails to state the hour at which the adjourned meeting is to be held, it shall be held at the hour specified for regular meetings by ordinance, resolution, bylaw, or other rule.

54955.1. Continuance

Any hearing being held, or noticed or ordered to be held, by a legislative body of a local agency at any meeting may by order or notice of continuance be continued or recontinued to any subsequent
meeting of the legislative body in the same manner and to the same extent set forth in Section 54955 for the adjournment of meetings; provided, that if the hearing is continued to a time less than 24 hours after the time specified in the order or notice of hearing, a copy of the order or notice of continuance of hearing shall be posted immediately following the meeting at which the order or declaration of continuance was adopted or made.

54956. Special meetings

A special meeting may be called at any time by the presiding officer of the legislative body of a local agency, or by a majority of the members of the legislative body, by delivering written notice to each member of the legislative body and to each local newspaper of general circulation and radio or television station requesting notice in writing. The notice shall be delivered personally or by any other means and shall be received at least 24 hours before the time of the meeting as specified in the notice. The call and notice shall specify the time and place of the special meeting and the business to be transacted or discussed. No other business shall be considered at these meetings by the legislative body. The written notice may be dispensed with as to any member who at or prior to the time the meeting convenes files with the clerk or secretary of the legislative body a written waiver of notice. The waiver may be given by telegram. The written notice may also be dispensed with as to any member who is actually present at the meeting at the time it convenes.

The call and notice shall be posted at least 24 hours prior to the special meeting in a location that is freely accessible to members of the public.

54956.5. Emergency meetings

(a) For purposes of this section, "emergency situation" means both of the following:

(1) An emergency, which shall be defined as a work stoppage, crippling activity, or other activity that severely impairs public health, safety, or both, as determined by a majority of the members of the legislative body.

(2) A dire emergency, which shall be defined as a crippling disaster, mass destruction, terrorist act, or threatened terrorist activity that poses peril so immediate and significant that requiring a legislative body to provide one-hour notice before holding an emergency meeting under this section may endanger the public health, safety, or both, as determined by a majority of the members of the legislative body.

(b) Subject to paragraph (2), in the case of an emergency situation involving matters upon which prompt action is necessary due to the disruption or threatened disruption of public facilities, a legislative body may hold an emergency meeting without complying with either the 24-hour notice requirement or the 24-hour posting requirement of Section 54956 or both of the notice and posting requirements.
(2) Each local newspaper of general circulation and radio or television station that has requested notice of special meetings pursuant to Section 54956 shall be notified by the presiding officer of the legislative body, or designee thereof, one hour prior to the emergency meeting, or, in the case of a dire emergency, at or near the time that the presiding officer or designee notifies the members of the legislative body of the emergency meeting. This notice shall be given by telephone and all telephone numbers provided in the most recent request of a newspaper or station for notification of special meetings shall be exhausted. In the event that telephone services are not functioning, the notice requirements of this section shall be deemed waived, and the legislative body, or designee of the legislative body, shall notify those newspapers, radio stations, or television stations of the fact of the holding of the emergency meeting, the purpose of the meeting, and any action taken at the meeting as soon after the meeting as possible.

(c) During a meeting held pursuant to this section, the legislative body may meet in closed session pursuant to Section 54957 if agreed to by a two-thirds vote of the members of the legislative body present, or, if less than two-thirds of the members are present, by a unanimous vote of the members present.

(d) All special meeting requirements, as prescribed in Section 54956 shall be applicable to a meeting called pursuant to this section, with the exception of the 24-hour notice requirement.

(e) The minutes of a meeting called pursuant to this section, a list of persons who the presiding officer of the legislative body, or designee of the legislative body, notified or attempted to notify, a copy of the rollcall vote, and any actions taken at the meeting shall be posted for a minimum of 10 days in a public place as soon after the meeting as possible.

54956.6. Fees

No fees may be charged by the legislative body of a local agency for carrying out any provision of this chapter, except as specifically authorized by this chapter.

54956.7. Closed session; License application of rehabilitated criminal

Whenever a legislative body of a local agency determines that it is necessary to discuss and determine whether an applicant for a license or license renewal, who has a criminal record, is sufficiently rehabilitated to obtain the license, the legislative body may hold a closed session with the applicant and the applicant’s attorney, if any, for the purpose of holding the discussion and making the determination. If the legislative body determines, as a result of the closed session, that the issuance or renewal of the license should be denied, the applicant shall be offered the opportunity to withdraw the application. If the applicant withdraws the application, no record shall be kept of the discussions or decisions made at the closed session and all matters relating to the closed session shall be confidential. If the applicant does not withdraw the application, the legislative body shall take action at the public meeting during which the closed session is held or at its next public meeting denying the application for the license but all matters relating to the closed session are confidential and shall not
be disclosed without the consent of the applicant, except in an action by an applicant who has been denied a license challenging the denial of the license.

54956.8.  Closed session; Real property negotiations

Notwithstanding any other provision of this chapter, a legislative body of a local agency may hold a closed session with its negotiator prior to the purchase, sale, exchange, or lease of real property by or for the local agency to grant authority to its negotiator regarding the price and terms of payment for the purchase, sale, exchange, or lease.

However, prior to the closed session, the legislative body of the local agency shall hold an open and public session in which it identifies its negotiators, the real property or real properties which the negotiations may concern, and the person or persons with whom its negotiators may negotiate.

For purposes of this section, negotiators may be members of the legislative body of the local agency.

For purposes of this section, “lease” includes renewal or renegotiation of a lease.

Nothing in this section shall preclude a local agency from holding a closed session for discussions regarding eminent domain proceedings pursuant to Section 54956.9.

54956.86.  Closed session; Health claims

Notwithstanding any other provision of this chapter, a legislative body of a local agency which provides services pursuant to Section 14087.3 of the Welfare and Institutions Code may hold a closed session to hear a charge or complaint from a member enrolled in its health plan if the member does not wish to have his or her name, medical status, or other information that is protected by federal law publicly disclosed. Prior to holding a closed session pursuant to this section, the legislative body shall inform the member, in writing, of his or her right to have the charge or complaint heard in an open session rather than a closed session.

54956.87.  Record exempt; Closed session; County health plan

(a) Notwithstanding any other provision of this chapter, the records of a health plan that is licensed pursuant to the Knox-Keene Health Care Service Plan Act of 1975 (Chapter 2.2 (commencing with Section 1340) of Division 2 of the Health and Safety Code) and that is governed by a county board of supervisors, whether paper records, records maintained in the management information system, or records in any other form, that relate to provider rate or payment determinations, allocation or distribution methodologies for provider payments, formulae or calculations for these payments, and contract negotiations with providers of health care for alternative rates are exempt from disclosure for a period of three years after the contract is fully executed. The transmission of the records, or the information contained therein in an alternative form, to the board
of supervisors shall not constitute a waiver of exemption from disclosure, and the records and information once transmitted to the board of supervisors shall be subject to this same exemption.

(b) Notwithstanding any other provision of law, the governing board of a health plan that is licensed pursuant to the Knox-Keene Health Care Service Plan Act of 1975 (Chapter 2.2 (commencing with Section 1340) of Division 2 of the Health and Safety Code) and that is governed by a county board of supervisors may order that a meeting held solely for the purpose of discussion or taking action on health plan trade secrets, as defined in subdivision (c) of Section 32106 of the Health and Safety Code, shall be held in closed session. The requirements of making a public report of action taken in closed session, and the vote or abstention of every member present, may be limited to a brief general description without the information constituting the trade secret.

(c) The governing board may delete the portion or portions containing trade secrets from any documents that were finally approved in the closed session held pursuant to subdivision (b) that are provided to persons who have made the timely or standing request.

(d) Nothing in this section shall be construed as preventing the governing board from meeting in closed session as otherwise provided by law.

(e) The provisions of this section shall not prevent access to any records by the Joint Legislative Audit Committee in the exercise of its powers pursuant to Article 1 (commencing with Section 10500) of Chapter 4 of Part 2 of Division 2 of Title 2. The provisions of this section also shall not prevent access to any records by the Department of Corporations in the exercise of its powers pursuant to Article 1 (commencing with Section 1340) of Chapter 2.2 of Division 2 of the Health and Safety Code.

54956.9. Closed session; Pending litigation

Nothing in this chapter shall be construed to prevent a legislative body of a local agency, based on advice of its legal counsel, from holding a closed session to confer with, or receive advice from, its legal counsel regarding pending litigation when discussion in open session concerning those matters would prejudice the position of the local agency in the litigation.

For purposes of this chapter, all expressions of the lawyer-client privilege other than those provided in this section are hereby abrogated. This section is the exclusive expression of the lawyer-client privilege for purposes of conducting closed-session meetings pursuant to this chapter.

For purposes of this section, “litigation” includes any adjudicatory proceeding, including eminent domain, before a court, administrative body exercising its adjudicatory authority, hearing officer, or arbitrator.

For purposes of this section, litigation shall be considered pending when any of the following circumstances exist:
(a) Litigation, to which the local agency is a party, has been initiated formally.

(b) (1) A point has been reached where, in the opinion of the legislative body of the local agency on the advice of its legal counsel, based on existing facts and circumstances, there is a significant exposure to litigation against the local agency.

(2) Based on existing facts and circumstances, the legislative body of the local agency is meeting only to decide whether a closed session is authorized pursuant to paragraph (1) of this subdivision.

(3) For purposes of paragraphs (1) and (2), “existing facts and circumstances” shall consist only of one of the following:

(A) Facts and circumstances that might result in litigation against the local agency but which the local agency believes are not yet known to a potential plaintiff or plaintiffs, which facts and circumstances need not be disclosed.

(B) Facts and circumstances, including, but not limited to, an accident, disaster, incident, or transactional occurrence that might result in litigation against the agency and that are known to a potential plaintiff or plaintiffs, which facts or circumstances shall be publicly stated on the agenda or announced.

(C) The receipt of a claim pursuant to the Tort Claims Act or some other written communication from a potential plaintiff threatening litigation, which claim or communication shall be available for public inspection pursuant to Section 54957.5.

(D) A statement made by a person in an open and public meeting threatening litigation on a specific matter within the responsibility of the legislative body.

(E) A statement threatening litigation made by a person outside an open and public meeting on a specific matter within the responsibility of the legislative body so long as the official or employee of the local agency receiving knowledge of the threat makes a contemporaneous or other record of the statement prior to the meeting, which record shall be available for public inspection pursuant to Section 54957.5. The records so created need not identify the alleged victim of unlawful or tortious sexual conduct or anyone making the threat on their behalf, or identify a public employee who is the alleged perpetrator of any unlawful or tortious conduct upon which a threat of litigation is based, unless the identity of the person has been publicly disclosed.

(F) Nothing in this section shall require disclosure of written communications that are privileged and not subject to disclosure pursuant to the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1).
(c) Based on existing facts and circumstances, the legislative body of the local agency has decided to initiate or is deciding whether to initiate litigation.

Prior to holding a closed session pursuant to this section, the legislative body of the local agency shall state on the agenda or publicly announce the subdivision of this section that authorizes the closed session. If the session is closed pursuant to subdivision (a), the body shall state the title of or otherwise specifically identify the litigation to be discussed, unless the body states that to do so would jeopardize the agency’s ability to effectuate service of process upon one or more unserved parties, or that to do so would jeopardize its ability to conclude existing settlement negotiations to its advantage.

A local agency shall be considered to be a “party” or to have a “significant exposure to litigation” if an officer or employee of the local agency is a party or has significant exposure to litigation concerning prior or prospective activities or alleged activities during the course and scope of that office or employment, including litigation in which it is an issue whether an activity is outside the course and scope of the office or employment.

§ 54956.95. Closed session; Insurance liability

(a) Nothing in this chapter shall be construed to prevent a joint powers agency formed pursuant to Article 1 (commencing with Section 6500) of Chapter 5 of Division 7 of Title 1, for purposes of insurance pooling, or a local agency member of the joint powers agency, from holding a closed session to discuss a claim for the payment of tort liability losses, public liability losses, or workers’ compensation liability incurred by the joint powers agency or a local agency member of the joint powers agency.

(b) Nothing in this chapter shall be construed to prevent the Local Agency Self-Insurance Authority formed pursuant to Chapter 5.5 (commencing with Section 6599.01) of Division 7 of Title 1, or a local agency member of the authority, from holding a closed session to discuss a claim for the payment of tort liability losses, public liability losses, or workers’ compensation liability incurred by the authority or a local agency member of the authority.

(c) Nothing in this section shall be construed to affect Section 54956.9 with respect to any other local agency.

54957. Closed session; Personnel and threat to public security

(a) Nothing contained in this chapter shall be construed to prevent the legislative body of a local agency from holding closed sessions with the Attorney General, district attorney, agency counsel, sheriff, or chief of police, or their respective deputies, or a security consultant or a security...
operations manager, on matters posing a threat to the security of public buildings, a threat to the security of essential public services, including water, drinking water, wastewater treatment, natural gas service, and electric service, or a threat to the public's right of access to public services or public facilities.

(b)(1) Subject to paragraph (2), nothing contained in this chapter shall be construed to prevent the legislative body of a local agency from holding closed sessions during a regular or special meeting to consider the appointment, employment, evaluation of performance, discipline, or dismissal of a public employee or to hear complaints or charges brought against the employee by another person or employee unless the employee requests a public session.

(2) As a condition to holding a closed session on specific complaints or charges brought against an employee by another person or employee, the employee shall be given written notice of his or her right to have the complaints or charges heard in an open session rather than a closed session, which notice shall be delivered to the employee personally or by mail at least 24 hours before the time for holding the session. If notice is not given, any disciplinary or other action taken by the legislative body against the employee based on the specific complaints or charges in the closed session shall be null and void.

(3) The legislative body also may exclude from the public or closed meeting, during the examination of a witness, any or all other witnesses in the matter being investigated by the legislative body.

(4) For the purposes of this subdivision, the term "employee" shall include an officer or an independent contractor who functions as an officer or an employee but shall not include any elected official, member of a legislative body or other independent contractors. Nothing in this subdivision shall limit local officials' ability to hold closed session meetings pursuant to Sections 1461, 32106, and 32155 of the Health and Safety Code or Sections 37606 and 37624.3 of the Government Code. Closed sessions held pursuant to this subdivision shall not include discussion or action on proposed compensation except for a reduction of compensation that results from the imposition of discipline.

§ 54957.1. Report at conclusion of closed session

(a) The legislative body of any local agency shall publicly report any action taken in closed session and the vote or abstention of every member present thereon, as follows:

(1) Approval of an agreement concluding real estate negotiations pursuant to Section 54956.8 shall be reported after the agreement is final, as specified below:

(A) If its own approval renders the agreement final, the body shall report that approval and the substance of the agreement in open session at the public meeting during which the closed session is held.
(B) If final approval rests with the other party to the negotiations, the local agency shall disclose the fact of that approval and the substance of the agreement upon inquiry by any person, as soon as the other party or its agent has informed the local agency of its approval.

(2) Approval given to its legal counsel to defend, or seek or refrain from seeking appellate review or relief, or to enter as an amicus curiae in any form of litigation as the result of a consultation under Section 54956.9 shall be reported in open session at the public meeting during which the closed session is held. The report shall identify, if known, the adverse party or parties and the substance of the litigation. In the case of approval given to initiate or intervene in an action, the announcement need not identify the action, the defendants, or other particulars, but shall specify that the direction to initiate or intervene in an action has been given and that the action, the defendants, and the other particulars shall, once formally commenced, be disclosed to any person upon inquiry, unless to do so would jeopardize the agency’s ability to effectuate service of process on one or more unserved parties, or that to do so would jeopardize its ability to conclude existing settlement negotiations to its advantage.

(3) Approval given to its legal counsel of a settlement of pending litigation, as defined in Section 54956.9, at any stage prior to or during a judicial or quasi-judicial proceeding shall be reported after the settlement is final, as specified below:

(A) If the legislative body accepts a settlement offer signed by the opposing party, the body shall report its acceptance and identify the substance of the agreement in open session at the public meeting during which the closed session is held.

(B) If final approval rests with some other party to the litigation or with the court, then as soon as the settlement becomes final, and upon inquiry by any person, the local agency shall disclose the fact of that approval, and identify the substance of the agreement.

(4) Disposition reached as to claims discussed in closed session pursuant to Section 54956.95 shall be reported as soon as reached in a manner that identifies the name of the claimant, the name of the local agency claimed against, the substance of the claim, and any monetary amount approved for payment and agreed upon by the claimant.

(5) Action taken to appoint, employ, dismiss, accept the resignation of, or otherwise affect the employment status of a public employee in closed session pursuant to Section 54957 shall be reported at the public meeting during which the closed session is held. Any report required by this paragraph shall identify the title of the position. The general requirement of this paragraph notwithstanding, the report of a dismissal or of the nonrenewal of an employment contract shall be deferred until the first public meeting following the exhaustion of administrative remedies, if any.
(6) Approval of an agreement concluding labor negotiations with represented employees pursuant to Section 54957.6 shall be reported after the agreement is final and has been accepted or ratified by the other party. The report shall identify the item approved and the other party or parties to the negotiation.

(b) Reports that are required to be made pursuant to this section may be made orally or in writing. The legislative body shall provide to any person who has submitted a written request to the legislative body within 24 hours of the posting of the agenda, or to any person who has made a standing request for all documentation as part of a request for notice of meetings pursuant to Section 54954.1 or 54956, if the requester is present at the time the closed session ends, copies of any contracts, settlement agreements, or other documents that were finally approved or adopted in the closed session. If the action taken results in one or more substantive amendments to the related documents requiring retyping, the documents need not be released until the retyping is completed during normal business hours, provided that the presiding officer of the legislative body or his or her designee orally summarizes the substance of the amendments for the benefit of the document requester or any other person present and requesting the information.

(c) The documentation referred to in paragraph (b) shall be available to any person on the next business day following the meeting in which the action referred to is taken or, in the case of substantial amendments, when any necessary retyping is complete.

(d) Nothing in this section shall be construed to require that the legislative body approve actions not otherwise subject to legislative body approval.

(e) No action for injury to a reputational, liberty, or other personal interest may be commenced by or on behalf of any employee or former employee with respect to whom a disclosure is made by a legislative body in an effort to comply with this section.

54957.2. Minutes of closed session

(a) The legislative body of a local agency may, by ordinance or resolution, designate a clerk or other officer or employee of the local agency who shall then attend each closed session of the legislative body and keep and enter in a minute book a record of topics discussed and decisions made at the meeting. The minute book made pursuant to this section is not a public record subject to inspection pursuant to the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), and shall be kept confidential. The minute book shall be available only to members of the legislative body or, if a violation of this chapter is alleged to have occurred at a closed session, to a court of general jurisdiction wherein the local agency lies. Such minute book may, but need not, consist of a recording of the closed session.

(b) An elected legislative body of a local agency may require that each legislative body all or a majority of whose members are appointed by or under the authority of the elected legislative body keep a minute book as prescribed under subdivision (a).
54957.5. Agendas and other materials; Public records

(a) Notwithstanding Section 6255 or any other provisions of law, agendas of public meetings and any other writings, when distributed to all, or a majority of all, of the members of a legislative body of a local agency by any person in connection with a matter subject to discussion or consideration at a public meeting of the body, are disclosable public records under the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), and shall be made available upon request without delay. However, this section shall not include any writing exempt from public disclosure under Section 6253.5, 6254, 6254.7, or 6254.22.

(b) Writings that are public records under subdivision (a) and that are distributed during a public meeting shall be made available for public inspection at the meeting if prepared by the local agency or a member of its legislative body, or after the meeting if prepared by some other person. These writings shall be made available in appropriate alternative formats upon request by a person with a disability, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof.

(c) Nothing in this chapter shall be construed to prevent the legislative body of a local agency from charging a fee or deposit for a copy of a public record pursuant to Section 6253, except that no surcharge shall be imposed on persons with disabilities in violation of Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof.

(d) This section shall not be construed to limit or delay the public's right to inspect or obtain a copy of any record required to be disclosed under the requirements of the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1). Nothing in this chapter shall be construed to require a legislative body of a local agency to place any paid advertisement or any other paid notice in any publication.

54957.6. Closed session; Labor negotiations

(a) Notwithstanding any other provision of law, a legislative body of a local agency may hold closed sessions with the local agency’s designated representatives regarding the salaries, salary schedules, or compensation paid in the form of fringe benefits of its represented and unrepresented employees, and, for represented employees, any other matter within the statutorily provided scope of representation.

However, prior to the closed session, the legislative body of the local agency shall hold an open and public session in which it identifies its designated representatives.

Closed sessions of a legislative body of a local agency, as permitted in this section, shall be for the purpose of reviewing its position and instructing the local agency’s designated representatives.
Closed sessions, as permitted in this section, may take place prior to and during consultations and discussions with representatives of employee organizations and unrepresented employees.

Closed sessions with the local agency’s designated representative regarding the salaries, salary schedules, or compensation paid in the form of fringe benefits may include discussion of an agency’s available funds and funding priorities, but only insofar as these discussions relate to providing instructions to the local agency’s designated representative.

Closed sessions held pursuant to this section shall not include final action on the proposed compensation of one or more unrepresented employees.

For the purposes enumerated in this section, a legislative body of a local agency may also meet with a state conciliator who has intervened in the proceedings.

(b) For the purposes of this section, the term “employee” shall include an officer or an independent contractor who functions as an officer or an employee, but shall not include any elected official, member of a legislative body, or other independent contractors.

54957.7. Announcement prior to closed sessions

(a) Prior to holding any closed session, the legislative body of the local agency shall disclose, in an open meeting, the item or items to be discussed in the closed session. The disclosure may take the form of a reference to the item or items as they are listed by number or letter on the agenda. In the closed session, the legislative body may consider only those matters covered in its statement. Nothing in this section shall require or authorize a disclosure of information prohibited by state or federal law.

(b) After any closed session, the legislative body shall reconvene into open session prior to adjournment and shall make any disclosures required by Section 54957.1 of action taken in the closed session.

(c) The announcements required to be made in open session pursuant to this section may be made at the location announced in the agenda for the closed session, as long as the public is allowed to be present at that location for the purpose of hearing the announcements.

54957.8. Closed session; Multijurisdictional drug enforcement agency

Nothing contained in this chapter shall be construed to prevent the legislative body of a multijurisdictional drug law enforcement agency, or an advisory body of a multijurisdictional drug law enforcement agency, from holding closed sessions to discuss the case records of any ongoing criminal
investigation of the multijurisdictional drug law enforcement agency or of any party to the joint powers agreement, to hear testimony from persons involved in the investigation, and to discuss courses of action in particular cases.

“Multijurisdictional drug law enforcement agency,” for purposes of this section, means a joint powers entity formed pursuant to Article 1 (commencing with Section 6500) of Chapter 5 of Division 7 of Title 1, which provides drug law enforcement services for the parties to the joint powers agreement.

The Legislature finds and declares that this section is within the public interest, in that its provisions are necessary to prevent the impairment of ongoing law enforcement investigations, to protect witnesses and informants, and to permit the discussion of effective courses of action in particular cases.

54957.9. Disruption of meeting

In the event that any meeting is willfully interrupted by a group or groups of persons so as to render the orderly conduct of such meeting unfeasible and order cannot be restored by the removal of individuals who are willfully interrupting the meeting, the members of the legislative body conducting the meeting may order the meeting room cleared and continue in session. Only matters appearing on the agenda may be considered in such a session. Representatives of the press or other news media, except those participating in the disturbance, shall be allowed to attend any session held pursuant to this section. Nothing in this section shall prohibit the legislative body from establishing a procedure for readmitting an individual or individuals not responsible for willfully disturbing the orderly conduct of the meeting.

54957.10. Closed session; Deferred Compensation Plan; Early withdrawal

Notwithstanding any other provision of law, a legislative body of a local agency may hold closed sessions to discuss a local agency employee’s application for early withdrawal of funds in a deferred compensation plan when the application is based on financial hardship arising from an unforeseeable emergency due to illness, accident, casualty, or other extraordinary event, as specified in the deferred compensation plan.

54958. Act supercedes conflicting laws

The provisions of this chapter shall apply to the legislative body of every local agency notwithstanding the conflicting provisions of any other state law.

54959. Violation of Act; Criminal penalty

Each member of a legislative body who attends a meeting of that legislative body where action is taken in violation of any provision of this chapter, and where the member intends to deprive the
public of information to which the member knows or has reason to know the public is entitled under this chapter, is guilty of a misdemeanor.

54960. Violation of Act; Civil remedies

(a) The district attorney or any interested person may commence an action by mandamus, injunction or declaratory relief for the purpose of stopping or preventing violations or threatened violations of this chapter by members of the legislative body of a local agency or to determine the applicability of this chapter to actions or threatened future action of the legislative body, or to determine whether any rule or action by the legislative body to penalize or otherwise discourage the expression of one or more of its members is valid or invalid under the laws of this state or of the United States, or to compel the legislative body to tape record its closed sessions as hereinafter provided.

(b) The court in its discretion may, upon a judgment of a violation of Section 54956.7, 54956.8, 54956.9, 54956.95, 54957, or 54957.6, order the legislative body to tape record its closed sessions and preserve the tape recordings for the period and under the terms of security and confidentiality the court deems appropriate.

(c) (1) Each recording so kept shall be immediately labeled with the date of the closed session recorded and the title of the clerk or other officer who shall be custodian of the recording.

(2) The tapes shall be subject to the following discovery procedures:

(A) In any case in which discovery or disclosure of the tape is sought by either the district attorney or the plaintiff in a civil action pursuant to Section 54959, 54960, or 54960.1 alleging that a violation of this chapter has occurred in a closed session which has been recorded pursuant to this section, the party seeking discovery or disclosure shall file a written notice of motion with the appropriate court with notice to the governmental agency which has custody and control of the tape recording. The notice shall be given pursuant to subdivision (b) of Section 1005 of the Code of Civil Procedure.

(B) The notice shall include, in addition to the items required by Section 1010 of the Code of Civil Procedure, all of the following:

(i) Identification of the proceeding in which discovery or disclosure is sought, the party seeking discovery or disclosure, the date and time of the meeting recorded, and the governmental agency which has custody and control of the recording.

(ii) An affidavit which contains specific facts indicating that a violation of the act occurred in the closed session.
(3) If the court, following a review of the motion, finds that there is good cause to believe that a violation has occurred, the court may review, in camera, the recording of that portion of the closed session alleged to have violated the act.

(4) If, following the in camera review, the court concludes that disclosure of a portion of the recording would be likely to materially assist in the resolution of the litigation alleging violation of this chapter, the court shall, in its discretion, make a certified transcript of the portion of the recording a public exhibit in the proceeding.

(5) Nothing in this section shall permit discovery of communications which are protected by the attorney-client privilege.

54960.1. Violation of Act; Actions declared null and void

(a) The district attorney or any interested person may commence an action by mandamus or injunction for the purpose of obtaining a judicial determination that an action taken by a legislative body of a local agency in violation of Section 54953, 54954.2, 54954.5, 54954.6, 54956, or 54956.5 is null and void under this section. Nothing in this chapter shall be construed to prevent a legislative body from curing or correcting an action challenged pursuant to this section.

(b) Prior to any action being commenced pursuant to subdivision (a), the district attorney or interested person shall make a demand of the legislative body to cure or correct the action alleged to have been taken in violation of Section 54953, 54954.2, 54954.5, 54954.6, 54956, or 54956.5. The demand shall be in writing and clearly describe the challenged action of the legislative body and nature of the alleged violation.

(c) (1) The written demand shall be made within 90 days from the date the action was taken unless the action was taken in an open session but in violation of Section 54954.2, in which case the written demand shall be made within 30 days from the date the action was taken.

(2) Within 30 days of receipt of the demand, the legislative body shall cure or correct the challenged action and inform the demanding party in writing of its actions to cure or correct or inform the demanding party in writing of its decision not to cure or correct the challenged action.

(3) If the legislative body takes no action within the 30-day period, the inaction shall be deemed a decision not to cure or correct the challenged action, and the 15-day period to commence the action described in subdivision (a) shall commence to run the day after the 30-day period to cure or correct expires.

(4) Within 15 days of receipt of the written notice of the legislative body's decision to cure or correct, or not to cure or correct, or within 15 days of the expiration of the 30-day period to cure or correct, whichever is earlier, the demanding party shall be required to commence the action pursuant to subdivision (a) or thereafter be barred from commencing the action.
(d) An action taken that is alleged to have been taken in violation of Section 54953, 54954.2, 54954.5, 54954.6, 54956, or 54956.5 shall not be determined to be null and void if any of the following conditions exist:

(1) The action taken was in substantial compliance with Sections 54953, 54954.2, 54954.5, 54954.6, 54956, and 54956.5.

(2) The action taken was in connection with the sale or issuance of notes, bonds, or other evidences of indebtedness or any contract, instrument, or agreement thereto.

(3) The action taken gave rise to a contractual obligation, including a contract let by competitive bid other than compensation for services in the form of salary or fees for professional services, upon which a party has, in good faith and without notice of a challenge to the validity of the action, detrimentally relied.

(4) The action taken was in connection with the collection of any tax.

(5) Any person, city, city and county, county, district, or any agency or subdivision of the state alleging noncompliance with subdivision (a) of Section 54954.2, Section 54956, or Section 54956.5, because of any defect, error, irregularity, or omission in the notice given pursuant to those provisions, had actual notice of the item of business at least 72 hours prior to the meeting at which the action was taken, if the meeting was noticed pursuant to Section 54954.2, or 24 hours prior to the meeting at which the action was taken if the meeting was noticed pursuant to Section 54956, or prior to the meeting at which the action was taken if the meeting is held pursuant to Section 54956.5.

(e) During any action seeking a judicial determination pursuant to subdivision (a) if the court determines, pursuant to a showing by the legislative body that an action alleged to have been taken in violation of Section 54953, 54954.2, 54954.5, 54954.6, 54956, or 54956.5 has been cured or corrected by a subsequent action of the legislative body, the action filed pursuant to subdivision (a) shall be dismissed with prejudice.

(f) The fact that a legislative body takes a subsequent action to cure or correct an action taken pursuant to this section shall not be construed or admissible as evidence of a violation of this chapter.

54960.5. Costs and attorney fees

A court may award court costs and reasonable attorney fees to the plaintiff in an action brought pursuant to Section 54960 or 54960.1 where it is found that a legislative body of the local agency has violated this chapter. The costs and fees shall be paid by the local agency and shall not become a personal liability of any public officer or employee of the local agency.
A court may award court costs and reasonable attorney fees to a defendant in any action brought pursuant to Section 54960 or 54960.1 where the defendant has prevailed in a final determination of such action and the court finds that the action was clearly frivolous and totally lacking in merit.

54961. Discrimination; Disabled access; Fees for attendance; Disclosure of victims

(a) No legislative body of a local agency shall conduct any meeting in any facility that prohibits the admittance of any person, or persons, on the basis of race, religious creed, color, national origin, ancestry, or sex, or which is inaccessible to disabled persons, or where members of the public may not be present without making a payment or purchase. This section shall apply to every local agency as defined in Section 54951.

(b) No notice, agenda, announcement, or report required under this chapter need identify any victim or alleged victim of tortious sexual conduct or child abuse unless the identity of the person has been publicly disclosed.

54962. Closed session; Express authorization required

Except as expressly authorized by this chapter, or by Sections 1461, 1462, 32106, and 32155 of the Health and Safety Code or Sections 37606 and 37624.3 of the Government Code as they apply to hospitals, or by any provision of the Education Code pertaining to school districts and community college districts, no closed session may be held by any legislative body of any local agency.

54963. Closed session; Disclosure of confidential information

(a) A person may not disclose confidential information that has been acquired by being present in a closed session authorized by Section 54956.7, 54956.8, 54956.86, 54956.87, 54956.9, 54957, 54957.6, 54957.8, or 54957.10 to a person not entitled to receive it, unless the legislative body authorizes disclosure of that confidential information.

(b) For purposes of this section, "confidential information" means a communication made in a closed session that is specifically related to the basis for the legislative body of a local agency to meet lawfully in closed session under this chapter.

(c) Violation of this section may be addressed by the use of such remedies as are currently available by law, including, but not limited to:

(1) Injunctive relief to prevent the disclosure of confidential information prohibited by this section.

(2) Disciplinary action against an employee who has willfully disclosed confidential information in violation of this section.
(3) Referral of a member of a legislative body who has willfully disclosed confidential information in violation of this section to the grandjury.

(d) Disciplinary action pursuant to paragraph (2) of subdivision (c) shall require that the employee in question has either received training as to the requirements of this section or otherwise has been given notice of the requirements of this section.

(e) A local agency may not take any action authorized by subdivision (c) against a person, nor shall it be deemed a violation of this section, for doing any of the following:

(1) Making a confidential inquiry or complaint to a district attorney or grand jury concerning a perceived violation of law, including disclosing facts to a district attorney or grand jury that are necessary to establish the illegality of an action taken by a legislative body of a local agency or the potential illegality of an action that has been the subject of deliberation at a closed session if that action were to be taken by a legislative body of a local agency.

(2) Expressing an opinion concerning the propriety or legality of actions taken by a legislative body of a local agency in closed session, including disclosure of the nature and extent of the illegal or potentially illegal action.

(3) Disclosing information acquired by being present in a closed session under this chapter that is not confidential information.

(f) Nothing in this section shall be construed to prohibit disclosures under the whistleblower statutes contained in Section 1102.5 of the Labor Code or Article 4.5 (commencing with Section 53296) of Chapter 2 of this code.
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Attorney General’s Office
Public Inquiry Unit
P.O. Box 944255
Sacramento, CA 94244-2550
1 (800) 952-5225
A Handy Guide to the Bagley-Keene Open Meeting Act 2004

By the California Attorney General’s Office
A Handy Guide
to
The Bagley-Keene Open Meeting Act 2004

California Attorney General’s Office
INTRODUCTION

The Bagley-Keene Open Meeting Act (“the Act” or “the Bagley-Keene Act”), set forth in Government Code sections 11120-11132, covers all state boards and commissions. Generally, it requires these bodies to publicly notice their meetings, prepare agendas, accept public testimony and conduct their meetings in public unless specifically authorized by the Act to meet in closed session. Following is a brief summary of the Act’s major provisions. Although we believe that this summary is a helpful road map, it is no substitute for consulting the actual language of the Act and the court cases and administrative opinions that interpret it.

If you wish to obtain additional copies of this pamphlet, they may be ordered or downloaded via the Attorney General’s Home Page, located on the World Wide Web at http://caag.state.ca.us. You may also write to the Attorney General’s Office, Public Inquiry Unit, P.O. Box 944255, Sacramento, CA 94244-2550 or call us at (800) 952-5225 (for callers within California), or (916) 322-3360 (for callers outside of California); the TTY/TDD telephone numbers are (800) 952-5548 (for callers within California), or (916) 324-5564 (for callers outside of California).

PURPOSE OF THE ACT

Operating under the requirements of the Act can sometimes be frustrating for both board members and staff. This results from the lack of efficiency built into the Act and the unnatural communication patterns brought about by compliance with its rules.

If efficiency were the top priority, the Legislature would create a department and then permit the department head to make decisions. However, when the Legislature creates a multimember board, it makes a different value judgment. Rather than striving strictly for efficiency, it concludes that there is a higher value to having a group of individuals with a variety of experiences, backgrounds and viewpoints come together to develop a consensus. Consensus is developed through debate, deliberation and give and take. This process can sometimes take a long time and is very different in character than the individual-decision-maker model.

Although some individual decision-makers follow a consensus-building model in the way that they make decisions, they’re not required to do so. When the Legislature creates a multimember body, it is mandating that the government go through this consensus building process.

When the Legislature enacted the Bagley-Keene Act, it imposed still another value judgment on the governmental process. In effect, the Legislature said that when a body sits down to develop its consensus, there needs to be a seat at the table reserved for the public. (§ 11120.) By reserving this place for the public, the Legislature has provided the public with the ability to monitor and participate in the decision-making process. If the body were permitted to meet in secret, the public’s role in the decision-making process would be negated. Therefore, absent a specific reason to keep

1All statutory references are to the Government Code.
the public out of the meeting, the public should be allowed to monitor and participate in the decision-making process.

If one accepts the philosophy behind the creation of a multimember body and the reservation of a seat at the table for the public, many of the particular rules that exist in the Bagley-Keene Act become much easier to accept and understand. Simply put, some efficiency is sacrificed for the benefits of greater public participation in government.

**BODIES COVERED BY THE ACT: General Rule**

The general rule for determining whether a body is covered by the Act involves a two part test (§ 11121(a)):

First, the Act covers multimember bodies. A multimember body is two or more people. Examples of multimember bodies are: state boards, commissions, committees, panels, and councils. Second, the body must be created by statute or required by law to conduct official meetings. If a body is created by statute, it is covered by the Act regardless of whether it is decision-making or advisory.

- **Advisory Bodies**

The Act governs two types of advisory bodies: (1) those advisory bodies created by the Legislature and (2) those advisory bodies having three or more members that are created by formal action of another body. (§11121(c).) If an advisory body created by formal action of another body has only two members, it is not covered by the Bagley-Keene Act. Accordingly, that body can do its business without worrying about the notice and open meeting requirements of the Act. However, if it consists of three people, then it would qualify as an advisory committee subject to the requirements of the Act.

When a body authorizes or directs an individual to create a new body, that body is deemed to have been created by formal action of the parent body even if the individual makes all decisions regarding composition of the committee. The same result would apply where the individual states an intention to create an advisory body but seeks approval or ratification of that decision by the body.

Finally, the body will probably be deemed to have acted by formal action whenever the chair of the body, acting in his or her official capacity, creates an advisory committee. Ultimately, unless the advisory committee is created by staff or an individual board member, independent of the body’s authorization or desires, it probably should be viewed as having been created by formal action of the body.
Delegated Body

The critical issue for this type of body is whether the committee exercises some power that has been delegated to it by another body. If the body has been delegated the power to act, it is a delegated committee. (§ 11121(b).) A classic example is the executive committee that is given authority to act on behalf of the entire body between meetings. Such executive committees are delegated committees and are covered by the requirements of the Act.

There is no specific size requirement for the delegated body. However, to be a body, it still must be comprised of multiple members. Thus, a single individual is not a delegated body.

Commissions Created by the Governor

The Act specifically covers commissions created by executive order. (§ 11121(a).) That leaves open two potential issues for resolution with respect to this type of body. First, what’s an executive order as opposed to other exercises of power by the Governor? Second, when is a body a “commission” within the meaning of this provision? There is neither case law nor an Attorney General opinion addressing either of these issues in this context.

Body Determined by Membership

The next kind of body is determined by who serves on it. Under this provision, a body becomes a state body when a member of a state body, in his or her official capacity, serves as a representative on another body, either public or private, which is funded in whole or in part by the representative’s state body. (§ 11121(d).) It does not come up often, but the Act should be consulted whenever a member of one body sits as a representative on another body.

In summary, the foregoing are the general types of bodies that are defined as state bodies under the Bagley-Keene Act. As will be discussed below, these bodies are subject to the notice and open meeting requirements of the Act.

Members-to-be

The open meeting provisions of the Act basically apply to new members at the time of their election or appointment, even if they have not yet started to serve. (§ 11121.95.) The purpose of this provision is to prevent newly appointed members from meeting secretly among themselves or with holdover members of a body in sufficient numbers so as to constitute a quorum. The Act also requires bodies to provide their new members with a copy of the Act. (§ 11121.9.) We recommend that this Handy Guide be used to satisfy that requirement.
WHAT IS A MEETING?

The issue of what constitutes a meeting is one of the more troublesome and controversial issues under the Act. A meeting occurs when a quorum of a body convenes, either serially or all together, in one place, to address issues under the body’s jurisdiction. (§ 11122.5.) Obviously, a meeting would include a gathering where members were debating issues or voting on them. But a meeting also includes situations in which the body is merely receiving information. To the extent that a body receives information under circumstances where the public is deprived of the opportunity to monitor the information provided, and either agree with it or challenge it, the open-meeting process is deficient.

Typically, issues concerning the definition of a meeting arise in the context of informal gatherings such as study sessions or pre-meeting get-togethers. The study session historically arises from the body’s desire to study a subject prior to its placement on the body’s agenda. However, if a quorum is involved, the study session should be treated as a meeting under the Act. With respect to pre-meeting briefings, this office opined that staff briefings of the city council a half hour before the noticed city council meeting to discuss the items that would appear on the council’s meeting agenda were themselves meetings subject to open meeting laws.\textsuperscript{2} To the extent that a briefing is desirable, this office recommends that the executive officer prepare a briefing paper which would then be available to the members of the body, as well as, to the public.

Serial Meetings

The Act expressly prohibits the use of direct communication, personal intermediaries, or technological devices that are employed by a majority of the members of the state body to develop a collective concurrence as to action to be taken on an item by the members of the state body outside of an open meeting. (§ 11122.5(b).) Typically, a serial meeting is a series of communications, each of which involves less than a quorum of the legislative body, but which taken as a whole involves a majority of the body’s members. For example, a chain of communications involving contact from member A to member B who then communicates with member C would constitute a serial meeting in the case of a five-person body. Similarly, when a person acts as the hub of a wheel (member A) and communicates individually with the various spokes (members B and C), a serial meeting has occurred. In addition, a serial meeting occurs when intermediaries for board members have a meeting to discuss issues. For example, when a representative of member A meets with representatives of members B and C to discuss an agenda item, the members have conducted a serial meeting through their representatives acting as intermediaries.

In the *Stockton Newspapers* case, the court concluded that a series of individual telephone calls between the agency attorney and the members of the body constituted a meeting. In that case, the attorney individually polled the members of the body for their approval on a real estate transaction. The court concluded that even though the meeting was conducted in a serial fashion, it nevertheless was a meeting for the purposes of the Act.

An executive officer may receive spontaneous input from board members on the agenda or on any other topic. But problems arise if there are systematic communications through which a quorum of the body acquires information or engages in debate, discussion, lobbying, or any other aspect of the deliberative process, either among themselves or between board members and the staff.

Although there are no cases directly on point, if an executive officer receives the same question on substantive matters addressed in an upcoming agenda from a quorum of the body, this office recommends that a memorandum addressing these issues be provided to the body and the public so they will receive the same information.

This office has opined that under the Brown Act (the counterpart to the Bagley-Keene Act which is applicable to local government bodies) that a majority of the board members of a local public agency may not e-mail each other to discuss current topics related to the body’s jurisdiction even if the e-mails are also sent to the secretary and chairperson of the agency, posted on the agency’s Internet website, and made available in printed form at the next public meeting of the board.

The prohibition applies only to communications employed by a quorum to develop a collective concurrence concerning action to be taken by the body. Conversations that advance or clarify a member’s understanding of an issue, or facilitate an agreement or compromise among members, or advance the ultimate resolution of an issue, are all examples of communications that contribute to the development of a concurrence as to action to be taken by the body. Accordingly, with respect to items that have been placed on an agenda or that are likely to be placed upon an agenda, members of state bodies should avoid serial communications of a substantive nature that involve a quorum of the body.

In conclusion, serial meeting issues will arise most commonly in connection with rotating staff briefings, telephone calls or e-mail communications among a quorum of board members. In these situations, part of the deliberative process by which information is received and processed, mulled over and discussed, is occurring without participation of the public.

Just remember, serial-meeting provisions basically mean that what the body can not do as a group it can not do through serial communications by a quorum of its members.

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4 Cal.Atty.Gen., Indexed Letter, No. IL 00-906 (February 20, 2001).
- **Contacts by the Public**

One of the more difficult areas has to do with the rights of the public to contact individual members. For example, a communication from a member of the public to discuss an issue does not violate the Act. (§ 11122.5(c)(1).) The difficulty arises when the individual contacts a quorum of the body.

So long as the body does not solicit or orchestrate such contacts, they would not constitute a violation of the Bagley-Keene Act. Whether its good policy for a body to allow these individual contacts to occur is a different issue.

- **Social Gatherings**

The Act exempts purely social situations from its coverage. (§ 11122.5(c)(5).) However, this construction is based on the premise that matters under the body’s jurisdiction will not be discussed or considered at the social occasion. It may be useful to remind board members to avoid “shop talk” at the social event. Typically, this is difficult because service on the body is their common bond.

- **Conferences and Retreats**

Conferences are exempt from the Act’s coverage so long as they are open to the public and involve subject matter of general interest to persons or bodies in a given field. (§ 11122.5(c)(2).) While in attendance at a conference, members of a body should avoid private discussions with other members of their body about subjects that may be on an upcoming agenda. However, if the retreat or conference is designed to focus on the laws or issues of a particular body it would no be exempt under the Act.

- **Teleconference Meetings**

The Act provides for audio or audio and visual teleconference meetings for the benefit of the public and the body. (§ 11123.) When a teleconference meeting is held, each site from which a member of the body participates must be accessible to the public. [Hence, a member cannot participate from his or her car, using a car phone or from his or her home, unless the home is open to the public for the duration of the meeting.] All proceedings must be audible and votes must be taken by rollcall. All other provisions of the Act also apply to teleconference meetings. For these reasons, we recommend that a properly equipped and accessible public building be utilized for teleconference meetings. This section does not prevent the body from providing additional locations from which the public may observe the proceedings or address the state body by electronic means.

**NOTICE AND AGENDA REQUIREMENTS**

The notice and agenda provisions require bodies to send the notice of its meetings to persons who have requested it. (§ 11125(a).) In addition, at least ten days prior to the meeting, bodies must
prepare an agenda of all items to be discussed or acted upon at the meeting. (§ 11125(b).) In practice, this usually translates to boards and commissions sending out the notice and agenda to all persons on their mailing lists. The notice needs to state the time and the place of the meeting and give the name, phone number and address of a contact person who can answer questions about the meeting and the agenda. (§ 11125(a).) The agenda needs to contain a brief description of each item to be transacted or discussed at the meeting, which as a general rule need not exceed 20 words in length. (§ 11125(b).)

The agenda items should be drafted to provide interested lay persons with enough information to allow them to decide whether to attend the meeting or to participate in that particular agenda item. Bodies should not label topics as “discussion” or “action” items unless they intend to be bound by such descriptions. Bodies should not schedule items for consideration at particular times, unless they assure that the items will not be considered prior to the appointed time.

The notice and agenda requirements apply to both open and closed meetings. There is a tendency to think that agendas need not be prepared for closed session items because the public cannot attend. But the public’s ability to monitor closed sessions directly depends upon the agenda requirement which tells the public what is going to be discussed.

**REGULAR MEETINGS**

The Act, itself, does not directly define the term “regular meeting.” Nevertheless, there are several references in the Act concerning regular meetings. By inference and interpretation, the regular meeting is a meeting of the body conducted under normal or ordinary circumstances. A regular meeting requires a 10-day notice. This simply means that at least 10 days prior to the meeting, notice of the meeting must be given along with an agenda that sufficiently describes the items of business to be transacted or discussed. (§§ 11125(a), 11125(b).) The notice for a meeting must also be posted on the Internet, and the web site address must be included on the written agenda. In addition, upon request by any person with a disability, the notice must be made available in appropriate alternative formats, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the applicable federal rules and regulations. The notice must contain information regarding the manner in which and the deadline by which a request for any disability-related modification or accommodation, including auxiliary aids or services, may be made by a person requiring these aids or services in order to participate in the meeting.

In two special situations, items may be added to the agenda within the 10-day notice period, provided that they are added and notice is given no later than 48 hours prior to the meeting. (§ 11125.) The first such situation is where the body concludes that the topic it wishes to add would qualify for an emergency meeting as defined in the Act. (§ 11125.3(a)(1).) The second situation is where there is a need for immediate action and the need for action came to the attention of the body after the agenda was mailed in accordance with the 10-day notice requirement. (§ 11125.3(a)(2).) This second situation requires a two-thirds vote or a unanimous vote if two-thirds of the members are not present.
Changes made to the agenda under this section must be delivered to the members of the body and to national wires services at least 48 hours before the meeting and must be posted on the Internet as soon as practicable.

SPECIAL MEETINGS

A few years ago, special meetings were added to the Act to provide relief to agencies that, due to the occurrence of unforeseen events, had a need to meet on short notice and were hamstrung by the Act’s 10-day notice requirement. (§ 11125.4.) The special meeting requires that notice be provided at least 48 hours before the meeting to the members of the body and all national wire services, along with posting on the Internet.

The purposes for which a body can call a special meeting are quite limited. Examples include pending litigation, legislation, licencing matters and certain personnel actions. At the commencement of the special meeting, the body is required to make a finding that the 10-day notice requirement would impose a substantial hardship on the body or that immediate action is required to protect the public interest and must provide a factual basis for the finding. The finding must be adopted by two-thirds vote and must contain articulable facts that support it. If all of these requirements are not followed, then the body can not convene the special meeting and the meeting must be adjourned.

EMERGENCY MEETINGS

The Act provides for emergency meetings in rare instances when there exists a crippling disaster or a work stoppage that would severely impair public health and safety. (§ 11125.5.) An emergency meeting requires a one-hour notice to the media and must be held in open session. The Act also sets forth a variety of other technical procedural requirements that must be satisfied.

PUBLIC PARTICIPATION

Since one of the purposes of the Act is to protect and serve the interests of the general public to monitor and participate in meetings of state bodies, bodies covered by the Act are prohibited from imposing any conditions on attendance at a meeting. (§ 11124.) For example, while the Act does not prohibit use of a sign-in sheet, notice must be clearly given that signing-in is voluntary and not a pre-requisite to either attending the meeting or speaking at the meeting. On the other hand, security measures that require identification in order to gain admittance to a government building are permitted so long as security personnel do not share the information with the body.

In addition, members of the public are entitled to record and to broadcast (audio and/or video) the meetings, unless to do so would constitute a persistent disruption. (§ 11124.1.)
To ensure public participation, the Legislature expressly afforded an opportunity to the public to speak or otherwise participate at meetings, either before or during the consideration of each agenda item. (§11125.7.) The Legislature also provided that at any meeting the body can elect to consider comments from the public on any matter under the body’s jurisdiction. And while the body cannot act on any matter not included on the agenda, it can schedule issues raised by the public for consideration at future meetings. Public comment protected by the Act includes criticism of the programs, policies and officials of the state body.

ACCESS TO RECORDS

Under the Act, the public is entitled to have access to the records of the body. (§ 11125.1.) In general, a record includes any form of writing. When materials are provided to a majority of the body either before or during the meeting, they must also be made available to the public without delay, unless the confidentiality of such materials is otherwise protected. Any records provided to the public, must be available in appropriate alternative formats, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the applicable federal rules and regulations, upon request by a person with a disability.

Notwithstanding the foregoing, the Act makes Government Code section 6254, the most comprehensive exemption under the California Public Records Act, applicable to records provided to the body. That is, if the record that is being provided to the board members is a record that is otherwise exempt from disclosure under section 6254 of the Government Code, then the record need not be disclosed to members of the public. (§ 11125.1(a).) However, the public interest balancing test, set forth in Government Code section 6255, is expressly made inapplicable to records provided to members of the body.

If an agency has received a request for records, the Public Records Act allows the agency to charge for their duplication. (§ 11125.1(c).) Please be aware that the Public Records Act limits the amount that can be charged to the direct cost of duplication. This has been interpreted to mean a pro-rata share of the equipment cost and probably a pro-rata share of the employee cost in order to make the copies. It does not include anything other than the mere reproduction of the records. (See,§ 6253.9 for special rules concerning computer records.) Accordingly, an agency may not recover for the costs of retrieving or redacting a record.

ACCESSABILITY OF MEETING LOCATIONS

The Act requires that the place and manner of the meeting be nondiscriminatory. (§ 11131.) As such, the body cannot discriminate on the basis of race, religion, national origin, etc. The meeting site must also be accessible to the disabled. Furthermore, the agency may not charge a fee for attendance at a meeting governed by the Act.
CLOSED SESSIONS

Although, as a general rule, all items placed on an agenda must be addressed in open session, the Legislature has allowed closed sessions in very limited circumstances, which will be discussed in detail below. Closed sessions may be held legally only if the body complies with certain procedural requirements. (§ 11126.3)

As part of the required general procedures, the closed session must be listed on the meeting agenda and properly noticed. (§ 11125(b).) Prior to convening into closed session, the body must publically announce those issues that will be considered in closed session. (§ 11126.3.) This can be done by a reference to the item as properly listed on the agenda. In addition, the agenda should cite the statutory authority or provision of the Act which authorizes the particular closed session. (§11125(b).) After the closed session has been completed, the body is required to reconvene in public. (§ 11126.3(f).) However, the body is required to make a report only where the body makes a decision to hire or fire an individual. (§ 11125.2.) Bodies under the Bagley-Keene Act are required to keep minutes of their closed sessions. (§ 11126.1.) Under the Act, these minutes are confidential, and are disclosable only to the board itself or to a reviewing court.

Courts have narrowly construed the Act’s closed-session exceptions. For example, voting by secret ballot at an open-meeting is considered to be an improper closed session. Furthermore, closed sessions may be improperly convened if they are attended by persons other than those directly involved in the closed session as part of their official duties.

- Personnel Exception

The personnel exception generally applies only to employees. (§ 11126(a) and (b).) However, a body’s appointment pursuant to subdivision (e) of Section 4 of Article VII of the California Constitution (usually the body’s executive director) has been designated an employee for purposes of the personnel exception. On the other hand, under the Act, members of the body are not to be considered employees, and there exists no personnel exception or other closed session vehicle for board members to deal with issues that may arise between them. Board elections, team building exercises, and efforts to address personality problems that may arise between members of the board, cannot be handled in closed session.

Only certain categories of subject matter may be considered at a closed session authorized under the personnel exception. (§ 11126(a)(1).) The purpose of the personnel exception is to protect the privacy of the employee, and to allow the board members to speak candidly. It can be used to consider appointments, employment, evaluation of performance, discipline or dismissal, as well as to hear charges or complaints about an employee’s actions. Although the personnel exception is appropriate for discussion of an employee’s competence or qualifications for appointment or employment, we do not think that discussion of employee compensation may be conducted in closed
session in light of an appellate court decision interpreting a similar exception in the Brown Act, (the counterpart to the Bagley-Keene Act which is applicable to local government bodies).

The Act requires compliance with specific procedures when the body addresses a complaint leveled against an employee by a third person or initiates a disciplinary action against an employee. Under either circumstance, the Act requires 24-hour written notice to the employee. (§ 11126(a)(2).) Failure to provide such notice voids any action taken in closed session.

Upon receiving notice, the employee has the right to insist that the matter be heard in public session. (§ 11126(a)(2).) However, the opposite is not true. Under the Act, an employee has no right to have the matter heard in closed session. If the body decides to hold an open session, the Bagley-Keene Act does not provide any other option for the employee. Considerations, such as the employee’s right to privacy, are not addressed under the Bagley-Keene Act.

If an employee asserts his or her right to have the personnel matter addressed in open session, the body must present the issues and information/evidence concerning the employee’s performance or conduct in the open session. However, the body is still entitled to conduct its deliberations in closed session. (§ 11126(a)(4).)

### Pending Litigation Exception

The purpose of the pending litigation exception is to permit the agency to confer with its attorney in circumstances where, if that conversation were to occur in open session, it would prejudice the position of the agency in the litigation. (§ 11126(e)(1).) The term “litigation” refers to an adjudicatory proceeding that is held in either a judicial or an administrative forum. (§11126(e)(2)(c)(iii).) For purposes of the Act, litigation is “pending” in three basic situations. (§11126(e)(2).) First, where the agency is a party to existing litigation. Secondly, where under existing facts and circumstances, the agency has substantial exposure to litigation. And thirdly, where the body is meeting for the purpose of determining whether to initiate litigation. All of these situations constitute pending litigation under the exception.

For purposes of the Bagley-Keene Act, the pending litigation exception constitutes the exclusive expression of the attorney-client privilege. (§ 11126(e)(2).) In general, this means that independent statutes and case law that deal with attorney-client privilege issues do not apply to interpretations of the pending litigation provision of the Bagley-Keene Act. Accordingly, the specific language of the Act must be consulted to determine what is authorized for discussion in closed session.

Because the purpose of the closed session exception is to confer with legal counsel, the attorney must be present during the entire closed session devoted to the pending litigation. The Act’s pending litigation exception covers both the receipt of advice from counsel and the making of

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litigation decisions (e.g., whether to file an action, and if so, what approach should be taken, whether settlement should be considered, and if so, what the settlement terms should be.

What happens in a situation where a body desires legal advice from counsel, but the Act’s pending litigation exception does not apply? In such a case, legal counsel can either (1) provide the legal advice orally and discuss it in open session; or (2) deliver a one-way legal advice memorandum to the board members. The memorandum would constitute a record containing an attorney-client privileged communication and would be protected from disclosure under section 6254(k) of the Public Records Act. (11125.1(a).) However, when the board members receive that memorandum, they may discuss it only in open session, unless there is a specific exception that applies which allows them to consider it in closed session.6

- **Deliberations Exception**

  The purpose of the deliberations exception is to permit a body to deliberate on decisions in a proceeding under the Administrative Procedures Act, or under similar provisions of law, in closed session. (§ 11126(c)(3).)

- **Real Property Exception**

  Under the Act, the real-property exception provides that the body can, in closed session, advise its negotiator in situations involving real estate transactions and in negotiations regarding price and terms of payment. (§ 11126(c)(7).) However, before meeting in closed session, the body must identify the specific parcel in question and the party with whom it is negotiating. Again, the Act requires that the body properly notice its intent to hold a closed session and to cite the applicable authority enabling it to do so.

- **Security Exception**

  A state body may, upon a two-thirds vote of those present, conduct a closed session to consider matters posing a potential threat of criminal or terrorist activity against the personnel, property, buildings, facilities, or equipment, including electronic data, owned, leased, or controlled by the state body, where disclosure of these considerations could adversely affect their safety or security. (11126(c)(18).) After such a closed session, the state body must reconvene in open session prior to adjournment and report that a closed session was held along with a description of the general nature of the matters considered, and whether any action was taken in closed session.

  Whenever a state body utilizes this closed session exception, it must also provide specific written notice to the Legislative Analyst who must retain this information for at least four years. (11126(c)(18)(D).) This closed session exception will sunset in 2006. (11126(h).)

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REMEDIES FOR VIOLATIONS

The Act provides for remedies and penalties in situations where violations have allegedly occurred. Depending on the particular circumstances, the decision of the body may be overturned (§ 11130.3), violations may be stopped or prevented (§ 11130), costs and fees may be awarded (§11130.5), and in certain situations, there may be criminal misdemeanor penalties imposed as well. (§ 11130.7.)

Within 90 days of a decision or action of the body, any interested person may file suit alleging a violation of the Act and seeking to overturn the decision or action. Among other things, such suit may allege an unauthorized closed session or an improperly noticed meeting. Although the body is permitted to cure and correct a violation so as to avoid having its decision overturned, this can be much like trying to put toothpaste back in the tube. If possible, the body should try to return to a point prior to when the violation occurred and then proceed properly. For example, if the violation involves improper notice, we recommend that the body invalidate its decision, provide proper notice, and start the process over. To the extent that information has been received, statements made, or discussions have taken place, we recommend that the body include all of this on the record to ensure that everyone is aware of these events and has had an opportunity to respond.

In certain situations where a body has violated the Act, the decision can not be set aside or overturned; namely, where the action taken concerned the issuance of bonds, the entering into contracts where there has been detrimental reliance, the collection of taxes, and, in situations where there has been substantial compliance with the requirements of the Act. (11130.3(b.).)

Another remedy in dealing with a violation of the Act involves filing a lawsuit to stop or prevent future violations of the Act. (§ 11130.) In general, these legal actions are filed as injunctions, writs of mandates, or suits for declaratory relief. The Legislature has also authorized the Attorney General, the District Attorney or any other interested person to use these remedies to seek judicial redress for past violations of the Act.

A prevailing plaintiff may recover the costs of suit and attorney’s fees from the body (not individual members). (§ 11130.5.) On the other hand, if the body prevails, it may recover attorney’s fees and costs only if the plaintiff’s suit was clearly frivolous and totally without merit.

The Act provides for misdemeanor penalties against individual members of the body if the member attends a meeting in violation of the Act with the intent to deprive the public of information to which he or she knows, or has reason to know, the public is entitled to receive. (§ 11130.7.)
# THE BAGLEY-KEENE OPEN MEETING ACT

**Government Code Sections 11120-11132**  
*(January 2004)*

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THE BAGLEY-KEENE OPEN MEETING ACT

Government Code Sections 11120-11132

§ 11120. Policy statement; requirement for open meetings

11120. It is the public policy of this state that public agencies exist to aid in the conduct of the people’s business and the proceedings of public agencies be conducted openly so that the public may remain informed.

In enacting this article the Legislature finds and declares that it is the intent of the law that actions of state agencies be taken openly and that their deliberation be conducted openly.

The people of this state do not yield their sovereignty to the agencies which serve them. The people, in delegating authority, do not give their public servants the right to decide what is good for the people to know and what is not good for them to know. The people insist on remaining informed so that they may retain control over the instruments they have created.

This article shall be known and may be cited as the Bagley-Keene Open Meeting Act.

§ 11121. State body

11121. As used in this article, “state body” means each of the following:

(a) Every state board, or commission, or similar multimember body of the state that is created by statute or required by law to conduct official meetings and every commission created by executive order.

(b) A board, commission, committee, or similar multimember body that exercises any authority of a state body delegated to it by that state body.

(c) An advisory board, advisory commission, advisory committee, advisory subcommittee, or similar multimember advisory body of a state body, if created by formal action of the state body or of any member of the state body, and if the advisory body so created consists of three or more persons.

(d) A board, commission, committee, or similar multimember body on which a member of a body that is a state body pursuant to this section serves in his or her official capacity as a representative of that state body and that is supported, in whole or in part, by funds provided by the state body, whether the multimember body is organized and operated by the state body or by a private corporation.
§ 11121.1. State body; exceptions

11121.1. As used in this article, “state body” does not include any of the following:

(a) State agencies provided for in Article VI of the California Constitution.

(b) Districts or other local agencies whose meetings are required to be open to the public pursuant to the Ralph M. Brown Act (Chapter 9 (commencing with Section 54950) of Part 1 of Division 2 of Title 5).

(c) State agencies provided for in Article IV of the California Constitution whose meetings are required to be open to the public pursuant to the Grunsky-Burton Open Meeting Act (Article 2.2 (commencing with Section 9027) of Chapter 1.5 of Part 1 of Division 2 of Title 2).

(d) State agencies when they are conducting proceedings pursuant to Section 3596.

(e) State agencies provided for in Section 109260 of the Health and Safety Code, except as provided in Section 109390 of the Health and Safety Code.

(f) State agencies provided for in Section 11770.5 of the Insurance Code.

(g) The Credit Union Advisory Committee established pursuant to Section 14380 of the Financial Code.

§ 11121.9. Requirement to provide law to members

11121.9. Each state body shall provide a copy of this article to each member of the state body upon his or her appointment to membership or assumption of office.

§ 11121.95. Application to persons who have not assumed office

11121.95. Any person appointed or elected to serve as a member of a state body who has not yet assumed the duties of office shall conform his or her conduct to the requirements of this article and shall be treated for purposes of this article as if he or she has already assumed office.

§ 11122. Action taken; defined

11122. As used in this article “action taken” means a collective decision made by the members of a state body, a collective commitment or promise by the members of the state body to make a positive or negative decision or an actual vote by the members of a state body when sitting as a body or entity upon a motion, proposal, resolution, order or similar action.
§ 11122.5. Meeting defined; exceptions

11122.5. (a) As used in this article, “meeting” includes any congregation of a majority of the members of a state body at the same time and place to hear, discuss, or deliberate upon any item that is within the subject matter jurisdiction of the state body to which it pertains.

(b) Except as authorized pursuant to Section 11123, any use of direct communication, personal intermediaries, or technological devices that is employed by a majority of the members of the state body to develop a collective concurrence as to action to be taken on an item by the members of the state body is prohibited.

(c) The prohibitions of this article do not apply to any of the following:

(1) Individual contacts or conversations between a member of a state body and any other person.

(2) The attendance of a majority of the members of a state body at a conference or similar gathering open to the public that involves a discussion of issues of general interest to the public or to public agencies of the type represented by the state body, provided that a majority of the members do not discuss among themselves, other than as part of the scheduled program, business of a specified nature that is within the subject matter jurisdiction of the state body. This paragraph is not intended to allow members of the public free admission to a conference or similar gathering at which the organizers have required other participants or registrants to pay fees or charges as a condition of attendance.

(3) The attendance of a majority of the members of a state body at an open and publicized meeting organized to address a topic of state concern by a person or organization other than the state body, provided that a majority of the members do not discuss among themselves, other than as part of the scheduled program, business of a specific nature that is within the subject matter jurisdiction of the state body.

(4) The attendance of a majority of the members of a state body at an open and noticed meeting of another state body or of a legislative body of a local agency as defined by Section 54951, provided that a majority of the members do not discuss among themselves, other than as part of the scheduled meeting, business of a specific nature that is within the subject matter jurisdiction of the other state body.

(5) The attendance of a majority of the members of a state body at a purely social or ceremonial occasion, provided that a majority of the members do not discuss among themselves business of a specific nature that is within the subject matter jurisdiction of the state body.

(6) The attendance of a majority of the members of a state body at an open and noticed meeting of a standing committee of that body, provided that the members of the state body who are not members of the standing committee attend only as observers.
§ 11123. Requirement for open meetings; teleconference meetings

11123. (a) All meetings of a state body shall be open and public and all persons shall be permitted to attend any meeting of a state body except as otherwise provided in this article.

(b)(1) This article does not prohibit a state body from holding an open or closed meeting by teleconference for the benefit of the public and state body. The meeting or proceeding held by teleconference shall otherwise comply with all applicable requirements or laws relating to a specific type of meeting or proceeding, including the following:

(A) The teleconferencing meeting shall comply with all requirements of this article applicable to other meetings.

(B) The portion of the teleconferenced meeting that is required to be open to the public shall be audible to the public at the location specified in the notice of the meeting.

(C) If the state body elects to conduct a meeting or proceeding by teleconference, it shall post agendas at all teleconference locations and conduct teleconference meetings in a manner that protects the rights of any party or member of the public appearing before the state body. Each teleconference location shall be identified in the notice and agenda of the meeting or proceeding, and each teleconference location shall be accessible to the public. The agenda shall provide an opportunity for members of the public to address the state body directly pursuant to Section 11125.7 at each teleconference location.

(D) All votes taken during a teleconferenced meeting shall be by rollcall.

(E) The portion of the teleconferenced meeting that is closed to the public may not include the consideration of any agenda item being heard pursuant to Section 11125.5.

(F) At least one member of the state body shall be physically present at the location specified in the notice of the meeting.

(2) For the purposes of this subdivision, “teleconference” means a meeting of a state body, the members of which are at different locations, connected by electronic means, through either audio or both audio and video. This section does not prohibit a state body from providing members of the public with additional locations in which the public may observe or address the state body by electronic means, through either audio or both audio and video.
§ 11123.1. Compliance with the ADA

11123.1. All meetings of a state body that are open and public shall meet the protections and prohibitions contained in Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof.

§ 11124. No conditions for attending meetings

11124. No person shall be required, as a condition to attendance at a meeting of a state body, to register his or her name, to provide other information, to complete a questionnaire, or otherwise to fulfill any condition precedent to his or her attendance. If an attendance list, register, questionnaire, or other similar document is posted at or near the entrance to the room where the meeting is to be held, or is circulated to persons present during the meeting, it shall state clearly that the signing, registering, or completion of the document is voluntary, and that all persons may attend the meeting regardless of whether a person signs, registers, or completes the document.

§ 11124.1. Right to record meetings

11124.1. (a) Any person attending an open and public meeting of the state body shall have the right to record the proceedings with an audio or video tape recorder or a still or motion picture camera in the absence of a reasonable finding by the state body that the recording cannot continue without noise, illumination, or obstruction of view that constitutes, or would constitute, a persistent disruption of the proceedings.

(b) Any tape or film record of an open and public meeting made for whatever purpose by or at the direction of the state body shall be subject to inspection pursuant to the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), but may be erased or destroyed 30 days after the taping or recording. Any inspection of an audio or video tape recording shall be provided without charge on an audio or video tape player made available by the state body.

(c) No state body shall prohibit or otherwise restrict the broadcast of its open and public meetings in the absence of a reasonable finding that the broadcast cannot be accomplished without noise, illumination, or obstruction of view that would constitute a persistent disruption of the proceedings.

§ 11125. Required notice

11125. (a) The state body shall provide notice of its meeting to any person who requests that notice in writing. Notice shall be given and also made available on the Internet at least 10 days in advance of the meeting, and shall include the name, address, and telephone number of any person who can provide further information prior to the meeting, but need not include a list of witnesses expected to appear at the meeting. The written notice shall additionally include the address of the Internet site where notices required by this article are made available.
(b) The notice of a meeting of a body that is a state body shall include a specific agenda for the meeting, containing a brief description of the items of business to be transacted or discussed in either open or closed session. A brief general description of an item generally need not exceed 20 words. A description of an item to be transacted or discussed in closed session shall include a citation of the specific statutory authority under which a closed session is being held. No item shall be added to the agenda subsequent to the provision of this notice, unless otherwise permitted by this article.

(c) Notice of a meeting of a state body that complies with this section shall also constitute notice of a meeting of an advisory body of that state body, provided that the business to be discussed by the advisory body is covered by the notice of the meeting of the state body, provided that the specific time and place of the advisory body’s meeting is announced during the open and public state body’s meeting, and provided that the advisory body’s meeting is conducted within a reasonable time of, and nearby, the meeting of the state body.

(d) A person may request, and shall be provided, notice pursuant to subdivision (a) for all meetings of a state body or for a specific meeting or meetings. In addition, at the state body’s discretion, a person may request, and may be provided, notice of only those meetings of a state body at which a particular subject or subjects specified in the request will be discussed.

(e) A request for notice of more than one meeting of a state body shall be subject to the provisions of Section 14911.

(f) The notice shall be made available in appropriate alternative formats, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof, upon request by any person with a disability. The notice shall include information regarding how, to whom, and by when a request for any disability-related modification or accommodation, including auxiliary aids or services may be made by a person with a disability who requires these aids or services in order to participate in the public meeting.

§ 11125.1. Agenda; writings provided to body; public records

11125.1. (a) Notwithstanding Section 6255 or any other provisions of law, agendas of public meetings and other writings, when distributed to all, or a majority of all, of the members of a state body by any person in connection with a matter subject to discussion or consideration at a public meeting of the body, are disclosable public records under the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), and shall be made available upon request without delay. However, this section shall not include any writing exempt from public disclosure under Section 6253.5, 6254, or 6254.7 of this code, or Section 489.1 or 583 of the Public Utilities Code.

(b) Writings that are public records under subdivision (a) and that are distributed to members of the state body prior to or during a meeting, pertaining to any item to be considered during the
meeting, shall be made available for public inspection at the meeting if prepared by the state body or a member of the state body, or after the meeting if prepared by some other person. These writings shall be made available in appropriate alternative formats, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof, upon request by a person with a disability.

(c) In the case of the Franchise Tax Board, prior to that state body taking final action on any item, writings pertaining to that item that are public records under subdivision (a) that are distributed to members of the state body by board staff or individual members prior to or during a meeting shall be:

(1) Made available for public inspection at that meeting.

(2) Distributed to all persons who request notice in writing pursuant to subdivision (a) of Section 11125.

(3) Made available on the Internet.

(d) Prior to the State Board of Equalization taking final action on any item that does not involve a named tax or fee payer, writings pertaining to that item that are public records under subdivision (a) that are prepared and distributed by board staff or individual members to members of the state body prior to or during a meeting shall be:

(1) Made available for public inspection at that meeting.

(2) Distributed to all persons who request or have requested copies of these writings.

(3) Made available on the Internet.

(e) Nothing in this section shall be construed to prevent a state body from charging a fee or deposit for a copy of a public record pursuant to Section 6253, except that no surcharge shall be imposed on persons with disabilities in violation of Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof. The writings described in subdivision (b) are subject to the requirements of the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), and shall not be construed to limit or delay the public’s right to inspect any record required to be disclosed by that act, or to limit the public’s right to inspect any record covered by that act. This section shall not be construed to be applicable to any writings solely because they are properly discussed in a closed session of a state body. Nothing in this article shall be construed to require a state body to place any paid advertisement or any other paid notice in any publication.

(f) “Writing” for purposes of this section means “writing” as defined under Section 6252.
§ 11125.2. Announcement of personnel action

11125.2. Any state body shall report publicly at a subsequent public meeting any action taken, and any rollcall vote thereon, to appoint, employ, or dismiss a public employee arising out of any closed session of the state body.

§ 11125.3. Exception to agenda requirements

11125.3. (a) Notwithstanding Section 11125, a state body may take action on items of business not appearing on the posted agenda under any of the conditions stated below:

(1) Upon a determination by a majority vote of the state body that an emergency situation exists, as defined in Section 11125.5.

(2) Upon a determination by a two-thirds vote of the state body, or, if less than two-thirds of the members are present, a unanimous vote of those members present, that there exists a need to take immediate action and that the need for action came to the attention of the state body subsequent to the agenda being posted as specified in Section 11125.

(b) Notice of the additional item to be considered shall be provided to each member of the state body and to all parties that have requested notice of its meetings as soon as is practicable after a determination of the need to consider the item is made, but shall be delivered in a manner that allows it to be received by the members and by newspapers of general circulation and radio or television stations at least 48 hours before the time of the meeting specified in the notice. Notice shall be made available to newspapers of general circulation and radio or television stations by providing that notice to all national press wire services. Notice shall also be made available on the Internet as soon as is practicable after the decision to consider additional items at a meeting has been made.

§ 11125.4. Special meetings

11125.4. (a) A special meeting may be called at any time by the presiding officer of the state body or by a majority of the members of the state body. A special meeting may only be called for one of the following purposes where compliance with the 10-day notice provisions of Section 11125 would impose a substantial hardship on the state body or where immediate action is required to protect the public interest:

(1) To consider “pending litigation” as that term is defined in subdivision (e) of Section 11126.

(2) To consider proposed legislation.

(3) To consider issuance of a legal opinion.
(4) To consider disciplinary action involving a state officer or employee.

(5) To consider the purchase, sale, exchange, or lease of real property.

(6) To consider license examinations and applications.

(7) To consider an action on a loan or grant provided pursuant to Division 31 (commencing with Section 50000) of the Health and Safety Code.

(b) When a special meeting is called pursuant to one of the purposes specified in subdivision (a), the state body shall provide notice of the special meeting to each member of the state body and to all parties that have requested notice of its meetings as soon as is practicable after the decision to call a special meeting has been made, but shall be delivered in a manner that allows it to be received by the members and by newspapers of general circulation and radio or television stations at least 48 hours before the time of the special meeting specified in the notice. Notice shall be made available to newspapers of general circulation and radio or television stations by providing that notice to all national press wire services. Notice shall also be made available on the Internet within the time periods required by this section. The notice shall specify the time and place of the special meeting and the business to be transacted. The written notice shall additionally specify the address of the Internet site where notices required by this article are made available. No other business shall be considered at a special meeting by the state body. The written notice may be dispensed with as to any member who at or prior to the time the meeting convenes files with the clerk or secretary of the state body a written waiver of notice. The waiver may be given by telegram, facsimile transmission, or similar means. The written notice may also be dispensed with as to any member who is actually present at the meeting at the time it convenes. Notice shall be required pursuant to this section regardless of whether any action is taken at the special meeting.

(c) At the commencement of any special meeting, the state body must make a finding in open session that the delay necessitated by providing notice 10 days prior to a meeting as required by Section 11125 would cause a substantial hardship on the body or that immediate action is required to protect the public interest. The finding shall set forth the specific facts that constitute the hardship to the body or the impending harm to the public interest. The finding shall be adopted by a two-thirds vote of the body, or, if less than two-thirds of the members are present, a unanimous vote of those members present. The finding shall be made available on the Internet. Failure to adopt the finding terminates the meeting.

§ 11125.5. Emergency meetings

11125.5. (a) In the case of an emergency situation involving matters upon which prompt action is necessary due to the disruption or threatened disruption of public facilities, a state body may hold an emergency meeting without complying with the 10-day notice requirement of Section 11125 or the 48-hour notice requirement of Section 11125.4.
(b) For purposes of this section, “emergency situation” means any of the following, as
determined by a majority of the members of the state body during a meeting prior to the emergency
meeting, or at the beginning of the emergency meeting:

(1) Work stoppage or other activity that severely impairs public health or safety, or both.

(2) Crippling disaster that severely impairs public health or safety, or both.

(c) However, newspapers of general circulation and radio or television stations that have
requested notice of meetings pursuant to Section 11125 shall be notified by the presiding officer of
the state body, or a designee thereof, one hour prior to the emergency meeting by telephone. Notice
shall also be made available on the Internet as soon as is practicable after the decision to call the
emergency meeting has been made. If telephone services are not functioning, the notice requirements
of this section shall be deemed waived, and the presiding officer of the state body, or a designee
thereof, shall notify those newspapers, radio stations, or television stations of the fact of the holding
of the emergency meeting, the purpose of the meeting, and any action taken at the meeting as soon
after the meeting as possible.

(d) The minutes of a meeting called pursuant to this section, a list of persons who the
presiding officer of the state body, or a designee thereof, notified or attempted to notify, a copy of
the rollcall vote, and any action taken at the meeting shall be posted for a minimum of 10 days in a
public place, and also made available on the Internet for a minimum of 10 days, as soon after the
meeting as possible.

§ 11125.6. Emergency meetings; Fish and Game Commission

11125.6. (a) An emergency meeting may be called at any time by the president of the Fish
and Game Commission or by a majority of the members of the commission to consider an appeal of
a closure of or restriction in a fishery adopted pursuant to Section 7710 of the Fish and Game Code.
In the case of an emergency situation involving matters upon which prompt action is necessary due
to the disruption or threatened disruption of an established fishery, the commission may hold an
emergency meeting without complying with the 10-day notice requirement of Section 11125 or the
48-hour notice requirement of Section 11125.4 if the delay necessitated by providing the 10-day
notice of a public meeting required by Section 11125 or the 48-hour notice required by Section
11125.4 would significantly adversely impact the economic benefits of a fishery to the participants
in the fishery and to the people of the state or significantly adversely impact the sustainability of a
fishery managed by the state.

(b) At the commencement of an emergency meeting called pursuant to this section, the
commission shall make a finding in open session that the delay necessitated by providing notice 10
days prior to a meeting as required by Section 11125 or 48 hours prior to a meeting as required by
Section 11125.4 would significantly adversely impact the economic benefits of a fishery to the
participants in the fishery and to the people of the state or significantly adversely impact the
sustainability of a fishery managed by the state. The finding shall set forth the specific facts that
constitute the impact to the economic benefits of the fishery or the sustainability of the fishery. The finding shall be adopted by a vote of at least four members of the commission, or, if less than four of the members are present, a unanimous vote of those members present. Failure to adopt the finding shall terminate the meeting.

(c) Newspapers of general circulation and radio or television stations that have requested notice of meetings pursuant to Section 11125 shall be notified by the presiding officer of the commission, or a designee thereof, one hour prior to the emergency meeting by telephone.

(d) The minutes of an emergency meeting called pursuant to this section, a list of persons who the president of the commission, or a designee thereof, notified or attempted to notify, a copy of the rollcall vote, and any action taken at the meeting shall be posted for a minimum of 10 days in a public place as soon after the meeting as possible.

§ 11125.7  Opportunity for public to speak at meeting

11125.7. (a) Except as otherwise provided in this section, the state body shall provide an opportunity for members of the public to directly address the state body on each agenda item before or during the state body’s discussion or consideration of the item. This section is not applicable if the agenda item has already been considered by a committee composed exclusively of members of the state body at a public meeting where interested members of the public were afforded the opportunity to address the committee on the item, before or during the committee’s consideration of the item, unless the item has been substantially changed since the committee heard the item, as determined by the state body. Every notice for a special meeting at which action is proposed to be taken on an item shall provide an opportunity for members of the public to directly address the state body concerning that item prior to action on the item. In addition, the notice requirement of Section 11125 shall not preclude the acceptance of testimony at meetings, other than emergency meetings, from members of the public, provided, however, that no action is taken by the state body at the same meeting on matters brought before the body by members of the public.

(b) The state body may adopt reasonable regulations to ensure that the intent of subdivision (a) is carried out, including, but not limited to, regulations limiting the total amount of time allocated for public comment on particular issues and for each individual speaker.

(c) The state body shall not prohibit public criticism of the policies, programs, or services of the state body, or of the acts or omissions of the state body. Nothing in this subdivision shall confer any privilege or protection for expression beyond that otherwise provided by law.

(d) This section is not applicable to closed sessions held pursuant to Section 11126.

(e) This section is not applicable to decisions regarding proceedings held pursuant to Chapter 5 (commencing with Section 11500), relating to administrative adjudication, or to the conduct of those proceedings.
(f) This section is not applicable to hearings conducted by the State Board of Control pursuant to Sections 13963 and 13963.1.

(g) This section is not applicable to agenda items that involve decisions of the Public Utilities Commission regarding adjudicatory hearings held pursuant to Chapter 9 (commencing with Section 1701) of Part 1 of Division 1 of the Public Utilities Code. For all other agenda items, the commission shall provide members of the public, other than those who have already participated in the proceedings underlying the agenda item, an opportunity to directly address the commission before or during the commission’s consideration of the item.

§ 11125.8. Closed session; Board of Control; crime victims

11125.8. (a) Notwithstanding Section 11131.5, in any hearing that the State Board of Control conducts pursuant to Section 13963.1 and that the applicant or applicant’s representative does not request be open to the public, no notice, agenda, announcement, or report required under this article need identify the applicant.

(b) In any hearing that the board conducts pursuant to Section 13963.1 and that the applicant or applicant’s representative does not request be open to the public, the board shall disclose that the hearing is being held pursuant to Section 13963.1. That disclosure shall be deemed to satisfy the requirements of subdivision (a) of Section 11126.3.

§ 11125.9. Regional water quality control boards; additional notice requirements

11125.9. Regional water quality control boards shall comply with the notification guidelines in Section 11125 and, in addition, shall do both of the following:

(a) Notify, in writing, all clerks of the city councils and county boards of supervisors within the regional board’s jurisdiction of any and all board hearings at least 10 days prior to the hearing. Notification shall include an agenda for the meeting with contents as described in subdivision (b) of Section 11125 as well as the name, address, and telephone number of any person who can provide further information prior to the meeting, but need not include a list of witnesses expected to appear at the meeting. Each clerk, upon receipt of the notification of a board hearing, shall distribute the notice to all members of the respective city council or board of supervisors within the regional board’s jurisdiction.

(b) Notify, in writing, all newspapers with a circulation rate of at least 10,000 within the regional board’s jurisdiction of any and all board hearings, at least 10 days prior to the hearing. Notification shall include an agenda for the meeting with contents as described in subdivision (b) of Section 11125 as well as the name, address, and telephone number of any person who can provide further information prior to the meeting, but need not include a list of witnesses expected to appear at the meeting.
§ 11126. Closed sessions

11126. (a)(1) Nothing in this article shall be construed to prevent a state body from holding closed sessions during a regular or special meeting to consider the appointment, employment, evaluation of performance, or dismissal of a public employee or to hear complaints or charges brought against that employee by another person or employee unless the employee requests a public hearing.

(2) As a condition to holding a closed session on the complaints or charges to consider disciplinary action or to consider dismissal, the employee shall be given written notice of his or her right to have a public hearing, rather than a closed session, and that notice shall be delivered to the employee personally or by mail at least 24 hours before the time for holding a regular or special meeting. If notice is not given, any disciplinary or other action taken against any employee at the closed session shall be null and void.

(3) The state body also may exclude from any public or closed session, during the examination of a witness, any or all other witnesses in the matter being investigated by the state body.

(4) Following the public hearing or closed session, the body may deliberate on the decision to be reached in a closed session.

(b) For the purposes of this section, “employee” does not include any person who is elected to, or appointed to a public office by, any state body. However, officers of the California State University who receive compensation for their services, other than per diem and ordinary and necessary expenses, shall, when engaged in that capacity, be considered employees. Furthermore, for purposes of this section, the term employee includes a person exempt from civil service pursuant to subdivision (e) of Section 4 of Article VII of the California Constitution.

(c) Nothing in this article shall be construed to do any of the following:

(1) Prevent state bodies that administer the licensing of persons engaging in businesses or professions from holding closed sessions to prepare, approve, grade, or administer examinations.

(2) Prevent an advisory body of a state body that administers the licensing of persons engaged in businesses or professions from conducting a closed session to discuss matters that the advisory body has found would constitute an unwarranted invasion of the privacy of an individual licensee or applicant if discussed in an open meeting, provided the advisory body does not include a quorum of the members of the state body it advises. Those matters may include review of an applicant’s qualifications for licensure and an inquiry specifically related to the state body’s enforcement program concerning an individual licensee or applicant where the inquiry occurs prior to the filing of a civil, criminal, or administrative disciplinary action against the licensee or applicant by the state body.
(3) Prohibit a state body from holding a closed session to deliberate on a decision to be reached in a proceeding required to be conducted pursuant to Chapter 5 (commencing with Section 11500) or similar provisions of law.

(4) Grant a right to enter any correctional institution or the grounds of a correctional institution where that right is not otherwise granted by law, nor shall anything in this article be construed to prevent a state body from holding a closed session when considering and acting upon the determination of a term, parole, or release of any individual or other disposition of an individual case, or if public disclosure of the subjects under discussion or consideration is expressly prohibited by statute.

(5) Prevent any closed session to consider the conferring of honorary degrees, or gifts, donations, and bequests that the donor or proposed donor has requested in writing to be kept confidential.

(6) Prevent the Alcoholic Beverage Control Appeals Board from holding a closed session for the purpose of holding a deliberative conference as provided in Section 11125.

(7) (A) Prevent a state body from holding closed sessions with its negotiator prior to the purchase, sale, exchange, or lease of real property by or for the state body to give instructions to its negotiator regarding the price and terms of payment for the purchase, sale, exchange, or lease.

(B) However, prior to the closed session, the state body shall hold an open and public session in which it identifies the real property or real properties that the negotiations may concern and the person or persons with whom its negotiator may negotiate.

(C) For purposes of this paragraph, the negotiator may be a member of the state body.

(D) For purposes of this paragraph, “lease” includes renewal or renegotiation of a lease.

(E) Nothing in this paragraph shall preclude a state body from holding a closed session for discussions regarding eminent domain proceedings pursuant to subdivision (e).

(8) Prevent the California Postsecondary Education Commission from holding closed sessions to consider matters pertaining to the appointment or termination of the Director of the California Postsecondary Education Commission.

(9) Prevent the Council for Private Postsecondary and Vocational Education from holding closed sessions to consider matters pertaining to the appointment or termination of the Executive Director of the Council for Private Postsecondary and Vocational Education.

(10) Prevent the Franchise Tax Board from holding closed sessions for the purpose of discussion of confidential tax returns or information the public disclosure of which is prohibited by
law, or from considering matters pertaining to the appointment or removal of the Executive Officer of the Franchise Tax Board.

(11) Require the Franchise Tax Board to notice or disclose any confidential tax information considered in closed sessions, or documents executed in connection therewith, the public disclosure of which is prohibited pursuant to Article 2 (commencing with Section 19542) of Chapter 7 of Part 10.2 of the Revenue and Taxation Code.

(12) Prevent the Board of Corrections from holding closed sessions when considering reports of crime conditions under Section 6027 of the Penal Code.

(13) Prevent the State Air Resources Board from holding closed sessions when considering the proprietary specifications and performance data of manufacturers.

(14) Prevent the State Board of Education or the Superintendent of Public Instruction, or any committee advising the board or the superintendent, from holding closed sessions on those portions of its review of assessment instruments pursuant to Chapter 5 (commencing with Section 60600) of, or pursuant to Chapter 8 (commencing with Section 60850) of, Part 33 of the Education Code during which actual test content is reviewed and discussed. The purpose of this provision is to maintain the confidentiality of the assessments under review.

(15) Prevent the California Integrated Waste Management Board or its auxiliary committees from holding closed sessions for the purpose of discussing confidential tax returns, discussing trade secrets or confidential or proprietary information in its possession, or discussing other data, the public disclosure of which is prohibited by law.

(16) Prevent a state body that invests retirement, pension, or endowment funds from holding closed sessions when considering investment decisions. For purposes of consideration of shareholder voting on corporate stocks held by the state body, closed sessions for the purposes of voting may be held only with respect to election of corporate directors, election of independent auditors, and other financial issues that could have a material effect on the net income of the corporation. For the purpose of real property investment decisions that may be considered in a closed session pursuant to this paragraph, a state body shall also be exempt from the provisions of paragraph (7) relating to the identification of real properties prior to the closed session.

(17) Prevent a state body, or boards, commissions, administrative officers, or other representatives that may properly be designated by law or by a state body, from holding closed sessions with its representatives in discharging its responsibilities under Chapter 10 (commencing with Section 3500), Chapter 10.3 (commencing with Section 3512), Chapter 10.5 (commencing with Section 3525), or Chapter 10.7 (commencing of Section 3540) of Division 4 of Title 1 as the sessions relate to salaries, salary schedules, or compensation paid in the form of fringe benefits. For the purposes enumerated in the preceding sentence, a state body may also meet with a state conciliator who has intervened in the proceedings.
(18) (A) Prevent a state body from holding closed sessions to consider matters posing a threat or potential threat of criminal or terrorist activity against the personnel, property, buildings, facilities, or equipment, including electronic data, owned, leased, or controlled by the state body, where disclosure of these considerations could compromise or impede the safety or security of the personnel, property, buildings, facilities, or equipment, including electronic data, owned, leased, or controlled by the state body.

(B) Notwithstanding any other provision of law, a state body, at any regular or special meeting, may meet in a closed session pursuant to subparagraph (A) upon a two-thirds vote of the members present at the meeting.

(C) After meeting in closed session pursuant to subparagraph (A), the state body shall reconvene in open session prior to adjournment and report that a closed session was held pursuant to subparagraph (A), the general nature of the matters considered, and whether any action was taken in closed session.

(D) After meeting in closed session pursuant to subparagraph (A), the state body shall submit to the Legislative Analyst written notification stating that it held this closed session, the general reason or reasons for the closed session, the general nature of the matters considered, and whether any action was taken in closed session. The Legislative Analyst shall retain for no less than four years any written notification received from a state body pursuant to this subparagraph.

(d)(1) Notwithstanding any other provision of law, any meeting of the Public Utilities Commission at which the rates of entities under the commission’s jurisdiction are changed shall be open and public.

(2) Nothing in this article shall be construed to prevent the Public Utilities Commission from holding closed sessions to deliberate on the institution of proceedings, or disciplinary actions against any person or entity under the jurisdiction of the commission.

(e) (1) Nothing in this article shall be construed to prevent a state body, based on the advice of its legal counsel, from holding a closed session to confer with, or receive advice from, its legal counsel regarding pending litigation when discussion in open session concerning those matters would prejudice the position of the state body in the litigation.

(2) For purposes of this article, all expressions of the lawyer-client privilege other than those provided in this subdivision are hereby abrogated. This subdivision is the exclusive expression of the lawyer-client privilege for purposes of conducting closed session meetings pursuant to this article. For purposes of this subdivision, litigation shall be considered pending when any of the following circumstances exist:

(A) An adjudicatory proceeding before a court, an administrative body exercising its adjudicatory authority, a hearing officer, or an arbitrator, to which the state body is a party, has been initiated formally.
(B)(i) A point has been reached where, in the opinion of the state body on the advice of its legal counsel, based on existing facts and circumstances, there is a significant exposure to litigation against the state body.

(ii) Based on existing facts and circumstances, the state body is meeting only to decide whether a closed session is authorized pursuant to clause (i).

(C)(i) Based on existing facts and circumstances, the state body has decided to initiate or is deciding whether to initiate litigation.

(ii) The legal counsel of the state body shall prepare and submit to it a memorandum stating the specific reasons and legal authority for the closed session. If the closed session is pursuant to paragraph (1), the memorandum shall include the title of the litigation. If the closed session is pursuant to subparagraph (A) or (B), the memorandum shall include the existing facts and circumstances on which it is based. The legal counsel shall submit the memorandum to the state body prior to the closed session, if feasible, and in any case no later than one week after the closed session. The memorandum shall be exempt from disclosure pursuant to Section 6254.25.

(iii) For purposes of this subdivision, “litigation” includes any adjudicatory proceeding, including eminent domain, before a court, administrative body exercising its adjudicatory authority, hearing officer, or arbitrator.

(iv) Disclosure of a memorandum required under this subdivision shall not be deemed as a waiver of the lawyer-client privilege, as provided for under Article 3 (commencing with Section 950) of Chapter 4 of Division 8 of the Evidence Code.

(f) In addition to subdivisions (a), (b), and (c), nothing in this article shall be construed to do any of the following:

1. Prevent a state body operating under a joint powers agreement for insurance pooling from holding a closed session to discuss a claim for the payment of tort liability or public liability losses incurred by the state body or any member agency under the joint powers agreement.

2. Prevent the examining committee established by the State Board of Forestry and Fire Protection, pursuant to Section 763 of the Public Resources Code, from conducting a closed session to consider disciplinary action against an individual professional forester prior to the filing of an accusation against the forester pursuant to Section 11503.

3. Prevent an administrative committee established by the California Board of Accountancy pursuant to Section 5020 of the Business and Professions Code from conducting a closed session to consider disciplinary action against an individual accountant prior to the filing of an accusation against the accountant pursuant to Section 11503. Nothing in this article shall be construed to prevent an examining committee established by the California Board of Accountancy pursuant to
Section 5023 of the Business and Professions Code from conducting a closed hearing to interview an individual applicant or accountant regarding the applicant’s qualifications.

(4) Prevent a state body, as defined in subdivision (b) of Section 11121, from conducting a closed session to consider any matter that properly could be considered in closed session by the state body whose authority it exercises.

(5) Prevent a state body, as defined in subdivision (d) of Section 11121, from conducting a closed session to consider any matter that properly could be considered in a closed session by the body defined as a state body pursuant to subdivision (a) or (b) of Section 11121.

(6) Prevent a state body, as defined in subdivision (c) of Section 11121, from conducting a closed session to consider any matter that properly could be considered in a closed session by the state body it advises.

(7) Prevent the State Board of Equalization from holding closed sessions for either of the following:

   (A) When considering matters pertaining to the appointment or removal of the Executive Secretary of the State Board of Equalization.

   (B) For the purpose of hearing confidential taxpayer appeals or data, the public disclosure of which is prohibited by law.

(8) Require the State Board of Equalization to disclose any action taken in closed session or documents executed in connection with that action, the public disclosure of which is prohibited by law pursuant to Sections 15619 and 15641 of this code and Sections 833, 7056, 8255, 9255, 11655, 30455, 32455, 38705, 38706, 43651, 45982, 46751, 50159, 55381, and 60609 of the Revenue and Taxation Code.

(9) Prevent the California Earthquake Prediction Evaluation Council, or other body appointed to advise the Director of the Office of Emergency Services or the Governor concerning matters relating to volcanic or earthquake predictions, from holding closed sessions when considering the evaluation of possible predictions.

   (g) This article does not prevent either of the following:

   (1) The Teachers’ Retirement Board or the Board of Administration of the Public Employees’ Retirement System from holding closed sessions when considering matters pertaining to the recruitment, appointment, employment, or removal of the chief executive officer or when considering matters pertaining to the recruitment or removal of the Chief Investment Officer of the State Teachers’ Retirement System or the Public Employees’ Retirement System.
(2) The Commission on Teacher Credentialing from holding closed sessions when considering matters relating to the recruitment, appointment, or removal of its executive director.

(h) This section shall remain in effect only until January 1, 2006, and as of that date is repealed, unless a later enacted statute, which is enacted before January 1, 2006, deletes or extends that date.

§ 11126.1. Minutes; availability

11126.1. The state body shall designate a clerk or other officer or employee of the state body, who shall then attend each closed session of the state body and keep and enter in a minute book a record of topics discussed and decisions made at the meeting. The minute book made pursuant to this section is not a public record subject to inspection pursuant to the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), and shall be kept confidential. The minute book shall be available to members of the state body or, if a violation of this chapter is alleged to have occurred at a closed session, to a court of general jurisdiction. Such minute book may, but need not, consist of a recording of the closed session.

§ 11126.3. Required notice for closed sessions

11126.3. (a) Prior to holding any closed session, the state body shall disclose, in an open meeting, the general nature of the item or items to be discussed in the closed session. The disclosure may take the form of a reference to the item or items as they are listed by number or letter on the agenda. If the session is closed pursuant to paragraph (2) of subdivision (d) of Section 11126, the state body shall state the title of, or otherwise specifically identify, the proceeding or disciplinary action contemplated. However, should the body determine that to do so would jeopardize the body’s ability to effectuate service of process upon one or more unserved parties if the proceeding or disciplinary action is commenced or that to do so would fail to protect the private economic and business reputation of the person or entity if the proceeding or disciplinary action is not commenced, then the state body shall notice that there will be a closed session and describe in general terms the purpose of that session. If the session is closed pursuant to subparagraph (A) of paragraph (2) of subdivision (e) of Section 11126, the state body shall state the title of, or otherwise specifically identify, the litigation to be discussed unless the body states that to do so would jeopardize the body’s ability to effectuate service of process upon one or more unserved parties, or that to do so would jeopardize its ability to conclude existing settlement negotiations to its advantage.

(b) In the closed session, the state body may consider only those matters covered in its disclosure.

(c) The disclosure shall be made as part of the notice provided for the meeting pursuant to Section 11125 or pursuant to subdivision (a) of Section 92032 of the Education Code and of any order or notice required by Section 11129.
(d) If, after the agenda has been published in compliance with this article, any pending litigation (under subdivision (e) of Section 11126) matters arise, the postponement of which will prevent the state body from complying with any statutory, court-ordered, or other legally imposed deadline, the state body may proceed to discuss those matters in closed session and shall publicly announce in the meeting the title of, or otherwise specifically identify, the litigation to be discussed, unless the body states that to do so would jeopardize the body’s ability to effectuate service of process upon one or more unserved parties, or that to do so would jeopardize its ability to conclude existing settlement negotiations to its advantage. Such an announcement shall be deemed to comply fully with the requirements of this section.

(e) Nothing in this section shall require or authorize a disclosure of names or other information that would constitute an invasion of privacy or otherwise unnecessarily divulge the particular facts concerning the closed session or the disclosure of which is prohibited by state or federal law.

(f) After any closed session, the state body shall reconvene into open session prior to adjournment and shall make any reports, provide any documentation, and make any other disclosures required by Section 11125.2 of action taken in the closed session.

(g) The announcements required to be made in open session pursuant to this section may be made at the location announced in the agenda for the closed session, as long as the public is allowed to be present at that location for the purpose of hearing the announcement.

§ 11126.5. Removal of disruptive persons

11126.5. In the event that any meeting is willfully interrupted by a group or groups of persons so as to render the orderly conduct of such meeting unfeasible and order cannot be restored by the removal of individuals who are willfully interrupting the meeting the state body conducting the meeting may order the meeting room cleared and continue in session. Nothing in this section shall prohibit the state body from establishing a procedure for readmitting an individual or individuals not responsible for willfully disturbing the orderly conduct of the meeting. Notwithstanding any other provision of law, only matters appearing on the agenda may be considered in such a session. Representatives of the press or other news media, except those participating in the disturbance, shall be allowed to attend any session held pursuant to this section.

§ 11126.7. Charging fees prohibited

11126.7. No fees may be charged by a state body for providing a notice required by Section 11125 or for carrying out any provision of this article, except as specifically authorized pursuant to this article.
§ 11127. State bodies covered

11127. Each provision of this article shall apply to every state body unless the body is specifically excepted from that provision by law or is covered by any other conflicting provision of law.

§ 11128. Time restrictions for holding closed sessions

11128. Each closed session of a state body shall be held only during a regular or special meeting of the body.

§ 11128.5. Adjournment

11128.5. The state body may adjourn any regular, adjourned regular, special, or adjourned special meeting to a time and place specified in the order of adjournment. Less than a quorum may so adjourn from time to time. If all members are absent from any regular or adjourned regular meeting, the clerk or secretary of the state body may declare the meeting adjourned to a stated time and place and he or she shall cause a written notice of the adjournment to be given in the same manner as provided in Section 11125.4 for special meetings, unless that notice is waived as provided for special meetings. A copy of the order or notice of adjournment shall be conspicuously posted on or near the door of the place where the regular, adjourned regular, special, or adjourned special meeting was held within 24 hours after the time of the adjournment. When a regular or adjourned regular meeting is adjourned as provided in this section, the resulting adjourned regular meeting is a regular meeting for all purposes. When an order of adjournment of any meeting fails to state the hour at which the adjourned meeting is to be held, it shall be held at the hour specified for regular meetings by law or regulation.

§ 11129. Continuation of meeting; notice requirement

11129. Any hearing being held, or noticed or ordered to be held by a state body at any meeting may by order or notice of continuance be continued or recontinued to any subsequent meeting of the state body in the same manner and to the same extent set forth in Section 11128.5 for the adjournment of meetings. A copy of the order or notice of continuance shall be conspicuously posted on or near the door of the place where the hearing was held within 24 hours after the time of the continuance; provided, that if the hearing is continued to a time less than 24 hours after the time specified in the order or notice of hearing, a copy of the order or notice of continuance of hearing shall be posted immediately following the meeting at which the order or declaration of continuance was adopted or made.

§ 11130. Legal remedies to stop or prohibit violations of act

11130. (a) The Attorney General, the district attorney, or any interested person may commence an action by mandamus, injunction, or declaratory relief for the purpose of stopping or preventing violations or threatened violations of this article or to determine the applicability of this
article to past actions or threatened future action by members of the state body or to determine whether any rule or action by the state body to penalize or otherwise discourage the expression of one or more of its members is valid or invalid under the laws of this state or of the United States, or to compel the state body to tape record its closed sessions as hereinafter provided.

(b) The court in its discretion may, upon a judgment of a violation of Section 11126, order the state body to tape record its closed sessions and preserve the tape recordings for the period and under the terms of security and confidentiality the court deems appropriate.

(c) (1) Each recording so kept shall be immediately labeled with the date of the closed session recorded and the title of the clerk or other officer who shall be custodian of the recording.

(2) The tapes shall be subject to the following discovery procedures:

(A) In any case in which discovery or disclosure of the tape is sought by the Attorney General, the district attorney, or the plaintiff in a civil action pursuant to this section or Section 11130.3 alleging that a violation of this article has occurred in a closed session that has been recorded pursuant to this section, the party seeking discovery or disclosure shall file a written notice of motion with the appropriate court with notice to the governmental agency that has custody and control of the tape recording. The notice shall be given pursuant to subdivision (b) of Section 1005 of the Code of Civil Procedure.

(B) The notice shall include, in addition to the items required by Section 1010 of the Code of Civil Procedure, all of the following:

(i) Identification of the proceeding in which discovery or disclosure is sought, the party seeking discovery or disclosure, the date and time of the meeting recorded, and the governmental agency that has custody and control of the recording.

(ii) An affidavit that contains specific facts indicating that a violation of the act occurred in the closed session.

(3) If the court, following a review of the motion, finds that there is good cause to believe that a violation has occurred, the court may review, in camera, the recording of that portion of the closed session alleged to have violated the act.

(4) If, following the in-camera review, the court concludes that disclosure of a portion of the recording would be likely to materially assist in the resolution of the litigation alleging violation of this article, the court shall, in its discretion, make a certified transcript of the portion of the recording a public exhibit in the proceeding.

(5) Nothing in this section shall permit discovery of communications that are protected by the attorney-client privilege.
§ 11130.3. Cause of action to void action

11130.3. (a) Any interested person may commence an action by mandamus, injunction, or declaratory relief for the purpose of obtaining a judicial determination that an action taken by a state body in violation of Section 11123 or 11125 is null and void under this section. Any action seeking such a judicial determination shall be commenced within 90 days from the date the action was taken. Nothing in this section shall be construed to prevent a state body from curing or correcting an action challenged pursuant to this section.

(b) An action shall not be determined to be null and void if any of the following conditions exist:

(1) The action taken was in connection with the sale or issuance of notes, bonds, or other evidences of indebtedness or any contract, instrument, or agreement related thereto.

(2) The action taken gave rise to a contractual obligation upon which a party has, in good faith, detrimentally relied.

(3) The action taken was in substantial compliance with Sections 11123 and 11125.

(4) The action taken was in connection with the collection of any tax.

§ 11130.5. Court costs; attorney’s fees

11130.5. A court may award court costs and reasonable attorney’s fees to the plaintiff in an action brought pursuant to Section 11130 or 11130.3 where it is found that a state body has violated the provisions of this article. The costs and fees shall be paid by the state body and shall not become a personal liability of any public officer or employee thereof. A court may award court costs and reasonable attorney’s fees to a defendant in any action brought pursuant to Section 11130 or 11130.3 where the defendant has prevailed in a final determination of the action and the court finds that the action was clearly frivolous and totally lacking in merit.

§ 11130.7. Violation; misdemeanor

11130.7. Each member of a state body who attends a meeting of that body in violation of any provision of this article, and where the member intends to deprive the public of information to which the member knows or has reason to know the public is entitled under this article, is guilty of a misdemeanor.

§ 11131. Prohibited meeting facilities; discrimination

11131. No state agency shall conduct any meeting, conference, or other function in any facility that prohibits the admittance of any person, or persons, on the basis of race, religious creed, color, national origin, ancestry, or sex, or that is inaccessible to disabled persons, or where members of the public may not be present without making a payment or purchase. As used in this section,
“state agency” means and includes every state body, office, officer, department, division, bureau, board, council, commission, or other state agency.

§ 11131.5. Required notice; exemption for name of victim

11131.5. No notice, agenda, announcement, or report required under this article need identify any victim or alleged victim of crime, tortious sexual conduct, or child abuse unless the identity of the person has been publicly disclosed.

§ 11132. Closed sessions; express authorization required

11132. Except as expressly authorized by this article, no closed session may be held by any state body.
Recent Water Legislation
By DWR Legislative Affairs Office
Recent Water Legislation

Legislative changes and programmatic actions within the last five years have provided new definition for planning for improved water supply reliability. In addition to the Water Bonds mentioned earlier, new legislation has focused on local water planning.

Improve Water Management and Integrated Planning

The California Legislature has produced several regulations to improve water management and integrated planning at the local level.

- **SB 1075 (Johnston, Chapter 583, Statutes of 1998) – Delta Protection Commission.** Senate Bill 1075 extends the Delta Protection Commission to January 1, 2010, and authorizes the commission to facilitate the implementation of any joint habitat-restoration programs within the primary zone of the Delta.

- **SB 1765 (Peace, Chapter 813, Statutes of 1998) – Colorado River Management Program.** Senate Bill 1765 appropriates funds to DWR. The funds are for lining the All American Canal and the Coachella Branch of the All American Canal and for other studies.

- **AB 1593 (Villaraigosa, Chapter 1017, Statutes of 1999) – Wild and Scenic Rivers: South Yuba River.** Assembly Bill 1593 designates the South Yuba River as “wild and scenic” to be effective January 1, 2001. This is the companion bill to SB 496.

- **SB 496 (Sher, Chapter 1016, Statutes of 1999) – Wild and Scenic Rivers: South Yuba River.** Senate Bill 496 adds the South Yuba River to the State’s wild and scenic rivers system. AB 1593 is the companion bill, which delays designation of the South Yuba River for 1 year.

- **SB 970 (Costa, Chapter 938, Statutes of 1999) – Water Rights.** Senate Bill 970 enacts the Water Rights Protection and Expedited Short-term Water Transfer Act of 1999 to streamline the administrative process for approval or denial of water transfers by the State Water Resources Control Board and requires general public notice of water transfers.

- **SB 1062 (Poochigian, Chapter 210, Statutes of 1999) - The California Water Plan.** Senate Bill 1062 requires DWR to include various strategies for meeting the state's water supply needs in its updates to the California Water Plan. The update must identify all federal and state permits, approvals or entitlements that might be required in order to implement the strategies. It also establishes an advisory committee to help DWR update the plan.

- **AB 1147 (Honda, Chapter 1071, Statutes of 2000) – Flood Control.** Assembly Bill 1147 establishes legislative intent for the Governor to establish a Floodplain Management Task force, provides for greater State oversight of flood control projects, changes the nonfederal cost share equation for flood control projects, and authorizes several flood control projects.

- **SB 1341 (Burton, Chapter 720, Statutes of 2000) - State Water Plan.** Senate Bill 1341 requires DWR to release a preliminary Draft of the California Water Plan’s water assumptions and estimates and restructures Water Code Section 10004 relevant to the California Water Plan.
• **SB 221 (Kuehl, Chapter 642, Statutes of 2001) - Certification of Sufficient Water Supply.** Senate Bill 221 requires local agencies to provide written verification that sufficient water supply is available before approving plans for new development.

• **SB 610 (Costa, Chapter 643, Statutes of 2001) - Water Supply Planning.** Senate Bill 610 requires additional information be included as part of an urban water management plan if groundwater is identified as a source of water available to the supplier. It requires an urban water supplier to include in the plan, a description of all water supply projects and programs that may be undertaken to meet total projected water use. In response to SB 221 and SB 610, DWR prepared *The State Water Project Delivery Reliability Report* to assist the SWP contractors in assessment of the adequacy of the SWP component of their overall water supplies. DWR has also published a guidebook on how cities and counties can comply with Senate Bills 221 and 610.

• **SB 672 (Machado, Chapter 320, Statutes of 2001) - Regional Planning & Water Plan Update.** Senate Bill 672 requires the State to include in the California Water Plan, a report on the development of regional and local water projects, within each hydrologic region to improve water supplies to meet municipal, agricultural, and environmental water needs and minimize the need to import water from other hydrologic regions. This bill also requires urban water suppliers to describe in their urban water management plans, water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.

• **AB 857 (Wiggins, Chapter 1016, Statutes of 2002) - State Strategic Planning.** Assembly Bill 857 establishes three specific planning priorities for the State:

1. To promote infill development and equity by rehabilitating, maintaining, and improving existing infrastructure that supports infill development and appropriate reuse and redevelopment of previously developed, underutilized land that is presently served by transit, streets, water, sewer, and other essential services, particularly in underserved areas, and to preserving cultural and historic resources.
2. To protect environmental and agricultural resources by protecting, preserving, and enhancing the state's most valuable natural resources, including working landscapes such as farm, range, and forest lands, natural lands such as wetlands, watersheds, wildlife habitats, and other wildlands, recreation lands such as parks, trails, greenbelts, and other open space, and landscapes with locally unique features and areas identified by the state as deserving special protection.
3. To encourage efficient development patterns by ensuring that any infrastructure associated with development that is not infill supports new development that uses land efficiently, is built adjacent to existing developed areas to the extent consistent with the priorities specified pursuant to subdivision (b), is in an area appropriately planned for growth, is served by adequate transportation and other essential utilities and services, and minimizes ongoing costs to taxpayers.

Additionally, this bill requires State agencies to ensure that their functional plans, which the California Water Plan is considered, are consistent with the State planning priorities by January 1, 2005, and to annually demonstrate how their requests for infrastructure projects are consistent with these priorities.
• **AB 2534 (Pavley, Chapter 727, Statutes of 2002) – Watershed, Clean Beaches, and Water Quality.** Assembly Bill 2534 provides $175 million in Proposition 40 funding as grants to public agencies and nonprofit organizations for projects designed to improve water quality at public beaches, improve water quality monitoring and sewer capability, reduce storm water runoff pollution, improve agricultural water quality and develop and implement local watershed management projects.

• **AB 2587 (Matthews, Chapter 615, Statutes of 2002) – Food: Water Usage Forecasts.** Assembly Bill 2587 requires the Department of Food and Agriculture to estimate food, fiber, livestock, and other farm products production and provide that information to the Department of Water Resources for estimating related water usage reported in Bulletin 160. The bill also states the intent of the Legislature that the food forecasts include the following considerations:

1. Neither the state nor the nation should be allowed to become dependent upon a net import of foreign food.
2. As the nation’s population grows, California should produce enough food to supply the state and also continue to supply the historical proportion of the nation’s food supply, approximately 25 percent of the nation’s table food.
3. Countries such as Japan are heavily dependent on imported food, some of which comes from California. California is also called upon to ship food to prevent famines and to protect our national interest by providing food to maintain stability elsewhere in the world. Consideration should be given to maintaining the state’s ability to meet these export needs.

• **SB 482 (Kuehl, Chapter 617, Statutes of 2002).** Senate Bill 482 was passed to help clear the way for the Colorado River Water Use Plan. Since the Plan could negatively impact some Salton Sea species, SB 482 permits the take of certain fully protected species found in the Salton Sea.

• **SB 1653 (Costa, Chapter 812, Statutes of 2002) – California Bay-Delta Act.** Senate Bill 1653 creates the California Bay-Delta Authority. The Authority will sunset on January 1, 2006, unless federal legislation has been enacted authorizing the participation of appropriate federal agencies in the Authority.

• **SB 1672 (Costa, Chapter 767, Statutes of 2002) - Integrated Regional Water Management Planning.** Senate Bill 1672 authorizes local public agencies to form regional water management groups and adopt regional plans to address “qualified programs or projects.” This bill requires DWR and other departments to give preference to “qualified programs or projects” when establishing criteria for funding under various programs.

• **SB 1938 (Machado, Chapter 603, Statutes of 2002) - Groundwater Management Plans.** Senate Bill 1938 requires a local agency, in order to qualify for state funds, to prepare and implement or consent to be subject to a groundwater management plan, a basinwide management plan, or other integrated regional water management program or plan that addresses five specific groundwater management components described in the bill. SB 1938 amended Water Code section 10750 et seq.
• **AB 1168 (Berg, Chapter 117, Statutes of 2003) - Albion and Gualala Rivers.** Assembly Bill 1168 includes segments of the Albion and Gualala Rivers within the California Wild and Scenic Rivers system and would designate those segments as recreational.

• **AB 1405 (Wolk, (Chapter 693, Statutes of 2003) - California Watershed Protection and Restoration.** Assembly Bill 1405 enacts the California Watershed Protection and Restoration Act to encourage the California Environmental Protection Agency and The Resources Agency to provide assistance and grants to those who choose to participate in watershed restoration and enhancements, and would declare that local collaborative watershed partnerships are in the State’s interest in terms of effectiveness, citizen involvement and community responsibility. This bill authorizes, to the extent funds are available, certain State agencies to provide technical assistance to local watershed partnerships and requires that State guidelines adopted for use by local watershed partnerships provide flexible mechanisms to achieve quantifiable watershed objectives.

• **SB 56 (Hollingsworth, Chapter 730, Statutes of 2003) - Water Development Projects: Murrieta Creek Project.** Senate Bill 56 authorizes the Murrieta Creek Flood Control Project in Riverside County. This bill authorizes the entire project on the downstream reach but only the fish, wildlife and recreation enhancement elements of the upstream reach of the project. It is the legislative intent that no State funds be appropriated for this project until July 1, 2013.

• **SB 277 (Ducheny, Chapter 611, Statutes of 2003) - Water: Salton Sea.** SB 277 is part of a triple-joined legislative package to implement the Colorado River Quantification Settlement Agreement; specifically, this bill: 1) enacts the Salton Sea Restoration Act; 2) establishes the Salton Sea Restoration Fund to fund various purposes relating to the restoration of the Salton Sea; 3) authorizes DWR to buy and sell water made available through voluntary reduction or elimination of water used to achieve the goals of the Salton Sea Restoration Act; and 4) requires the Department of Food and Agriculture, if funds are appropriated for the activity, to review and report on the nature and extent of any economic impacts related to the Quantification Settlement Agreement in the Imperial Valley.

• **SB 317 (Kuehl, Chapter 612, Statutes of 2003) - Resources.** Senate Bill 317 is part of a triple-joined legislative package to implement the Colorado River Quantification Settlement Agreement. This bill provides the funding mechanisms for restoration of the Salton Sea ecosystem, in part through sale of transferred water, and directs The Resources Agency to develop a preferred alternative for restoration of the Salton Sea ecosystem.

• **SB 654 (Machado, Chapter 613, Statutes of 2003) - Water: Salton Sea: Colorado River.** Senate Bill 654 is part of a triple-joined legislative package to implement the Colorado River Quantification Settlement Agreement. This bill authorizes the Department of Fish and Game to enter into a joint powers agreement with QSA parties to provide for payment of environmental mitigation costs, and extends the completion date of the lining of the All-American Canal and the Coachella Branch of the All-American Canal to December 31, 2008.

• **AB 107 (Steinberg, Chapter 498, Statutes of 2004) – Flood Control Standards.** Assembly Bill 107 adds a section to the Water Code permitting the governing board of local flood control agencies, under the jurisdiction of The Reclamation Board, authority to adopt prospective encroachments.
standards that are more protective of public safety than those adopted by the Board, subject to its approval and revision.

- **AB 1020 (Steinberg, Chapter 749, Statutes of 2004) – Flood Control: Local Cooperation.**
  Assembly Bill 1020 authorizes the Sacramento Area Flood Control Agency (SAFCA), at the discretion of The Reclamation Board, to provide assurances of local cooperation for the South Sacramento County Streams Project in lieu of those same assurances by the Board. The purpose of this bill is to authorize SAFCA to provide to the federal government, with Board approval, the assurances necessary for federal participation in the South Sacramento Streams Group project.

- **AB 2141 (Longville, Chapter 878, Statutes of 2004) – Floodplain Management: Alluvial Fan Task Force.**
  Assembly Bill 2141 requires that the Director of DWR establish the Alluvial Fan Task Force, with prescribed membership determined by the Director, review the state of knowledge regarding alluvial fan floodplains, to develop a model ordinance on alluvial fan flooding and prepare recommendations relating to alluvial fan floodplain management. This bill authorizes the Director to enter into an interagency agreement with an appropriate agency to oversee the Task Force. The bill does not allow for the use of State funds for implementation.

- **AB 2717 (Laird, Chapter 682, Statutes of 2004) – California Urban Water Conservation Council.**
  Assembly Bill 2717 declares the Legislature’s intent that the California Urban Water Conservation Council be requested to form a stakeholders workgroup composed of public and private representatives to evaluate and report on the Model Water Efficient Landscape Ordinance, water budgets for landscapes, incentives to encourage efficiency and other matters. State agency stakeholders are not required to pay any expenses of the workgroup and contributions from non-State stakeholders are strictly voluntary. This bill is permissive.

- **SB 117 (Machado, Chapter 716, Statutes of 2004) – Water Security, Clean Water, Coastal Protection.**
  Senate Bill 117 requires each State agency, implementing a Proposition 50 bond program, to provide technical assistance and outreach to disadvantaged communities and authorizes each agency to waive matching fund requirements at its discretion.

- **SB 1214 (Kuehl, Chapter 614, Statutes of 2004) – Salton Sea Restoration: Restoration Study.**
  Senate Bill 1214 provides further details of the Salton Sea Restoration Study required by the Salton Sea Restoration Act and requires that alternatives be identified in a restoration plan to be developed by The Resources Agency. The bill also sets forth some of the functions and duties of the Salton Sea Advisory Committee created by SB 317 (Kuehl) - Chapter 612, Statutes of 2003.

- **SB 1280 (Ortiz, Chapter 616, Statutes of 2004) – Flood Damage Reduction: American River Watershed.**
  Senate Bill 1280 authorizes the American River Watershed Project in Sacramento County. The bill requires the Sacramento Area Flood Control Agency to enter into an agreement with DWR in which SAFCA agrees to indemnify and hold harmless the State for any and all liability arising out of the flood control project authorized by this bill. The adopted and authorized project is in accordance with federal law and the cost to the State shall be later appropriated by the California Legislature on the recommendation of DWR or The Reclamation Board.
• **SB 1889 (Senate Environmental Quality, Chapter 744, Statutes of 2004) - Environmental Protection: Actions Against Agency.** This bill adds to CEQA a statutory definition of "trustee agency," patterned on CEQA Guideline 15386, to be any State agency with jurisdiction over natural resources that are held in trust for the people and are affected by a project. Requires, consistent with CEQA Guideline 15086, a State or local lead agency, prior to completing an environmental impact report, to consult with each trustee agency with resources affected by the project. Requires, consistent with CEQA Guideline 15063, a State or local lead agency, prior to determining whether an environmental impact report, negative declaration or mitigated negative declaration is required for the project to consult with each trustee agency.

• **AB 466 (Matthews, Chapter 567, Statutes of 2005) - Natural resources: Department of Fish and Game: California Bay-Delta** Assembly Bill 466 authorizes DWR to expend State funds to carry out the Alluvial Fan Task Force, if State funds are used to provide a matching cost share, as required by the federal government for the use of federal funds. The bill contains other related provisions relating to contracting services for scientific experts employed by the California Bay-Delta Authority for delta fish studies, and an appropriation to the Department of Fish and Game to continue development of a comprehensive conservation plan for the development of the University of California Merced project.

• **AB 1200 (Laird, Chapter 573, Statutes of 2005) - Sacramento-San Joaquin Delta.** Assembly Bill 1200 requires DWR to evaluate the potential impacts on water supplies derived from the Sacramento-San Joaquin Delta resulting from subsidence, earthquakes, floods, changes in precipitation, temperature, and ocean levels, and a combination of those impacts. Requires DWR and DFG to identify, evaluate, and comparatively rate the principal options available to implement certain objectives that relate to the delta or the Sacramento and San Joaquin river systems. Requires the departments to jointly report to the Legislature and the Governor the results of their evaluations and comparative ratings no later than January 1, 2008. The requirements of this bill are very similar to an existing study being conducted by DWR and DFG.

• **AB 1328 (Wolk – Chapter 576, Statutes of 2005) - Wild and scenic rivers: Cache Creek.** Assembly Bill 1328 includes various sections of Cache Creek, located in Lake and Yolo Counties, within the California Wild and Scenic River system. This bill protects existing and future water rights for various public water agencies within the Cache Creek watershed; provides that the wild and scenic designation would not hinder any efforts to remove invasive plant species or toxic substances from the river; and, prohibits the State from petitioning for a federal wild and scenic designation of the river.

• **SB 264 (Machado, Chapter 583, Statutes of 2005) - Delta Flood Protection Fund: delta levee maintenance.** Senate Bill 264 extends the existence of the Delta Flood Protection Fund until July 1, 2008 to help implement the delta levee maintenance subventions program.

• **SB 347 (Ortiz, Chapter 584, Statutes of 2005) - Flood control: American River flood damage reduction project.** Senate Bill 347 requires the State to cost share the funding for construction of a bridge at Folsom Dam as part of the Folsom Dam Mini-Raise project. The State cost share shall be at least $5.2 million, but shall not exceed $9 million. Requires the City of Folsom to serve as the
nonfederal sponsor of the bridge and to enter into a hold harmless agreement with the Department of Water Resources.

- **SB 826 (Maldonado, Chapter 687, Statutes of 2005) - State maintenance areas.** Senate Bill 826 requires The Reclamation Board or DWR, as applicable, to proceed with the formation of a maintenance area in accordance with specified procedures for any project for which a local agency has submitted an application for the formation of the maintenance area to DWR on or before July 1, 2003. Requires DWR and the local agency to sign an indemnity agreement holding the State harmless for any damages arising out of the design, operation, maintenance, repair or rehabilitation of the project or dissolution or modification of a maintenance area. (Note: the only project this bill would apply to is a proposed project located at Arroyo Grande in San Luis Obispo County.)

**Recycling, Desalination and Groundwater Potential for Increasing Supplies**

- **AB 303 (Thomson, Chapter 708, Statutes of 2000) – Groundwater.** Assembly Bill 303 enacts the Local Groundwater Management Assistance Act of 2000 to establish a grant program within DWR to provide funding to local public agencies to implement groundwater monitoring and management activities.

- **AB 331 (Goldberg, Chapter 590, Statutes of 2001) - 2002 Recycled Water Task Force.** Assembly Bill 331 requires DWR to report to the Legislature by July 1, 2003, on opportunities for increasing the use of recycled water in industrial and commercial applications and identify the constraints and impediments to increasing such use. The bill requires DWR to convene the Recycled Water Task Force with specified members who would advise the Department on preparing the report. The bill requires the DWR to carry out the provisions only to the extent that funds from the Safe Drinking Water, Clean Water, Watershed Protection and Flood Protection Act (Proposition 13) are made available by the State Water Resources Control Board.

- **AB 599 (Liu, Chapter 522, Statutes of 2001)—The Groundwater Quality Monitoring Act of 2001.** Assembly Bill 599 requires the State Water Resources Control Board to integrate existing monitoring programs and design new program elements for the purpose of establishing a comprehensive groundwater quality monitoring program to assess all groundwater basins in the State. This bill requires SWRCB to create an interagency task force to assist SWRCB in designing the monitoring program and requires SWRCB to convene an advisory committee to assist the interagency group. This bill requires a multiagency report to the Governor and the Legislature by January 1, 2002, on the status of implementation of the new law.

- **SB 1191 (Speier, Chapter 745, Statutes of 2001) –State and Local Reporting Requirements.** Senate Bill 1191 eliminates specific legislatively mandated reports, which are prepared by the Department.

- **AB 2717 (Hertzberg, Chapter 957, Statutes of 2002) – State Desalination Task Force.** Assembly Bill 2717 requires DWR, no later than July 1, 2004, to report to the Legislature on potential opportunities and impediments for using seawater and brackish water desalination, and to examine
what role, if any, the state should play in furthering the use of desalination technology. Rather than accepting the $600,000 appropriation in the bill, Governor Davis reduced the appropriation to $100,000 and directed DWR to explore funding partnerships with interested local and private entities to accomplish the study.

- **SB 1518 (Torlakson, Chapter 261, Statutes of 2002) – Recycled Water.** Senate Bill 1518 allows sanitation districts, after proper notification, to provide recycled water within the boundaries of a city, water district or other local agency that also provides similar water service. This bill requires that specific information about the use of recycled water be added to urban water management plans.

- **AB 314 (Kehoe, Chapter 206, Statutes of 2003) – Desalination.** Assembly Bill 314 declares that it is the policy of the State that desalination projects, developed by or for public water entities, be given the same opportunities for State assistance and funding as other water supply and reliability projects. This bill also declares that desalination be consistent with both State water supply and efficiency policy goals and joint State-federal environmental and water policy and principles promoted by the CALFED Bay-Delta Program.

- **AB 514 (Kehoe, Chapter 680, Statutes of 2003) – Water Meters.** Assembly Bill 514 requires that on or before January 1, 2013, an urban water supplier that, on or after January 1, 2004, receives water from the federal Central Valley Project under a water service contract or subcontract, must install water meters on service connections to residential and nonagricultural commercial buildings constructed prior to January 1, 1992. On and after March 1, 2013, or according to the terms of a CVP water contract, the water purveyor would be required to charge its customers for water based on the actual volume of measured deliveries and could also recover the cost related to installation and operation of the water meters from its rates, fees or charges.

- **AB 318 (Alpert, Chapter 688, Statutes of 2004) – Urban Water Suppliers: Desalination Water.** Assembly Bill 318 requires that an Urban Water Management Plan contain a description of the opportunities for development of desalinated water, including but not limited to, ocean water, brackish water and groundwater as a long-term supply. The new information required by this bill provides valuable information for decision-making bodies at all levels of government concerning the opportunities for improving water supplies and water supply reliability through the exploration of desalination technology throughout the State.

- **AB 2572 (Kehoe, Chapter 884, Statutes of 2004) – Water Meters.** Assembly Bill 2572 requires all urban water suppliers, as defined: (a) to install water meters on all municipal and industrial water service connections on or before January 1, 2005; and (b) on or before January 1, 2010 to charge each customer that has a service connection for which a meter has been installed, based on volume of deliveries, as measured by the water meter.

- **AB 2733 (Strickland, Chapter 535, Statutes of 2004) – Water Resources.** Assembly Bill 2733 requires each person who extracts groundwater in a State Water Resources Control Board designated local area and who is otherwise subject to provisions of existing law, to file the required notice with a local public agency or court appointed watermaster that has been designated by the
Board to receive the notice instead of the Board. Requires the local agency to undertake certain actions and provides authority for charging a fee for related administrative expenses.

- **AB 2918 (Laird, Chapter 648, Statutes of 2004) – Desalination Facilities.** Assembly Bill 2918 authorizes the California Public Utilities Commission to evaluate the interrelationship between PUC’s electricity policies and water policies as they relate to saline water conversion through ocean desalination. The evaluation required by this bill begins to address the recommendations of the Water Desalination Task Force.

- **SB 1155 (Machado, Chapter 612, Statutes of 2004) – Water Quality Standards: Sacramento-San Joaquin Delta.** Senate Bill 1155 requires the Director of DWR, in collaboration with the Secretary of Interior, to prepare a plan to meet existing permit and license conditions for which DWR has an obligation under the State Water Resources Control Board Decision 1641. Requires the plan to be prepared on or before January 1, 2006, and submitted to SWRCB and the California Bay-Delta Authority prior to increasing the existing permitted diversion rate at the State Water Project at Harvey O. Banks Pumping Plant.

- **SB 1319 (Burton/Alpert, Chapter 719, Statutes of 2004) – Natural Resources: Ocean Protection.** Senate Bill 1319 enacts the California Ocean Protection Act, which creates the Ocean Protection Council and establishes the California Ocean Protection Trust Fund. The purpose of this bill is to streamline and consolidate oversight of California’s ocean resources, designate ocean and marine ecosystems as a public trust, promote ocean protection policies based on sound science and facilitate the designation of marine protected areas. DWR does not have a direct role or special expertise in ocean resources protection; however, DWR’s interest in SB 1319 is specifically related to DWR’s role in administering the Chapter 6(a) Desalination Program authorized by Proposition 50.
Water Bonds
Water Bonds

Voters have approved three additional major California water bonds since the last Water Plan Update:

• **Proposition 13.** In March 2000, California voters approved Proposition 13 (2000 Water Bond), which authorizes the State of California to sell $1.97 billion in general obligation bonds to support safe drinking, water quality, flood protection and water reliability projects throughout the State.

• **Proposition 40.** In March 2002, California voters approved Proposition 40, a $2.6 billion state bond measure for conservation, neighborhood parks, and coastline and watershed protection. Proposition 40 was the largest conservation bond measure ever approved in California.

• **Proposition 50.** In November 2002, the $3.4 billion water bond measure, the largest in California history, was approved by voters. It provides $825 million in funding for CALFED for a variety of programs, including surface water storage studies, water conveyance facilities, levee improvements, water supply reliability projects, ecosystem restoration, watershed programs, conservation and water recycling. More on Proposition 50 is available at www.water.ca.gov/grants-loans.
Water Plan Legislation
Water Plan Legislation

Legislation that is directly related to California Water Plan Update 2005 is listed in this article.

CALIFORNIA WATER CODE SECTION 10004-10013

DIVISION 6. CONSERVATION, DEVELOPMENT, AND UTILIZATION OF STATE WATER RESOURCES

PART 1. ADOPTION OF STATE WATER PLAN ......................... 10000-10003
PART 1.5. THE CALIFORNIA WATER PLAN ...................... 10004-10013

10004. (a) The plan for the orderly and coordinated control, protection, conservation, development, and utilization of the water resources of the state which is set forth and described in Bulletin No. 1 of the State Water Resources Board entitled "Water Resources of California," Bulletin No. 2 of the State Water Resources Board entitled, "Water Utilization and Requirements of California," and Bulletin No. 3 of the department entitled, "The California Water Plan," with any necessary amendments, supplements, and additions to the plan, shall be known as "The California Water Plan."

(b) (1) The department shall update The California Water Plan on or before December 31, 2003, and every five years thereafter. The department shall report the amendments, supplements, and additions included in the updates of The California Water Plan, together with a summary of the department's conclusions and recommendations, to the Legislature in the session in which the updated plan is issued.

(2) The department shall establish an advisory committee, comprised of representatives of agricultural and urban water suppliers, local government, business, production agriculture, and environmental interests, and other interested parties, to assist the department in the updating of The California Water Plan. The department shall consult with the advisory committee in carrying out this section. The department shall provide written notice of meetings of the advisory committee to any interested person or entity that request the notice. The meetings shall be open to the public.

(3) The department shall release a preliminary draft of The California Water Plan, as updated, upon request, to interested persons and entities throughout the state for their review and comments. The department shall provide these persons and entities an opportunity to present written or oral comments on the preliminary draft. The department shall consider these comments in the preparation of the final publication of The California Water Plan, as updated.

10004.5. As part of the requirement of the department to update The California Water Plan pursuant to subdivision (b) of Section 10004, the department shall include in the plan a discussion of various strategies, including, but not limited to, those relating to the development of new water storage facilities, water conservation, water recycling, desalination, conjunctive use, and water transfers that may be pursued in order to meet the future water needs of the state. The department shall also include a discussion of the potential for alternative water pricing policies to change current and projected uses. The department shall include in the plan a discussion of the potential advantages and disadvantages of each strategy and an identification of all federal and state permits, approvals, or entitlements that are anticipated to be required in order to implement the various components of the strategy.

10004.6. (a) As part of updating The California Water Plan every five years pursuant to subdivision (b) of Section 10004, the department shall conduct a study to determine the amount of water needed to meet
the state's future needs and to recommend programs, policies, and facilities to meet those needs. (b) The department shall consult with the advisory committee established pursuant to subdivision (b) of Section 10004 in carrying out this section.

(c) On or before January 1, 2002, and one year prior to issuing each successive update to The California Water Plan, the department shall release a preliminary draft of the assumptions and other estimates upon which the study will be based, to interested persons and entities throughout the state for their review and comments. The department shall provide these persons and entities an opportunity to present written or oral comments on the preliminary draft. The department shall consider these documents when adopting the final assumptions and estimates for the study. For the purpose of carrying out this subdivision, the department shall release, at a minimum, assumptions and other estimates relating to all of the following:

1. Basin hydrology, including annual rainfall, estimated unimpaired stream flow, depletions, and consumptive uses.
2. Groundwater supplies, including estimates of sustainable yield, supplies necessary to recover overdraft basins, and supplies lost due to pollution and other groundwater contaminants.
3. Current and projected land use patterns, including the mix of residential, commercial, industrial, agricultural, and undeveloped lands.
4. Environmental water needs, including regulatory instream flow requirements, nonregulated instream uses, and water needs by wetlands, preserves, refuges, and other managed and unmanaged natural resource lands.
5. Current and projected population.
6. Current and projected water use for all of the following:
   A) Interior uses in a single-family dwelling.
   B) Exterior uses in a single-family dwelling.
   C) All uses in a multifamily dwelling.
   D) Commercial uses.
   E) Industrial uses.
   F) Parks and open spaces.
7. Evapotranspiration rates for major crop types, including estimates of evaporative losses by irrigation practice and the extent to which evaporation reduces transpiration.
8. Current and projected adoption of urban and agricultural conservation practices.
9. Current and projected supplies of water provided by water recycling and reuse.
(d) The department shall include a discussion of the potential for alternative water pricing policies to change current and projected water uses identified pursuant to paragraph (6) of subdivision (c).
(e) Nothing in this section requires or prohibits the department from updating any data necessary to update The California Water Plan pursuant to subdivision (b) of Section 10004.

10005. (a) It is hereby declared that the people of the state have a primary interest in the orderly and coordinated control, protection, conservation, development, and utilization of the water resources of the state by all individuals and entities and that it is the policy of the state that The California Water Plan, with any necessary amendments, supplements, and additions to the plan, is accepted as the master plan which guides the orderly and coordinated control, protection, conservation, development, management and efficient utilization of the water resources of the state.

(b) The declaration set forth in subdivision (a) does not constitute approval for the construction of specific projects or routes for transfer of water, or for financial assistance, by the state, without further legislative action, nor shall the declaration be construed as a prohibition of the development of the water
resources of the state by any entity.

10005.1. The department or, at the department's request, the California Water Commission, shall conduct a series of hearings with interested persons, organizations, local, state, and federal agencies, and representatives of the diverse geographical areas and interests of the state.

10005.2. Prior to holding a hearing pursuant to Section 10005.1, the department shall give notice by mail of the hearing to persons and entities which have requested notice and have provided their name and address to the department.

10006. The provisions of this part do not repeal or modify any of the provisions of Part 3 of this division.

10007. Notwithstanding anything contained in this part, all applications heretofore filed by the Department of Finance or by the Department of Water Resources under Part 2 of Division 6 shall remain valid and shall retain and have the status and priority accorded to such applications as now or hereafter provided in said Part 2.

10008. The Legislature hereby finds and declares that agreements which provide for the transfer of water from the federal Central Valley Project to public entities supplying water for domestic or irrigation use offer potential benefits to California's hard-pressed farmers and to California's water-dependent urban areas. It is the intent of the Legislature that these contracts be entered into for the purposes of strengthening California's economy, serving the public, and protecting the environment.

The director shall continue to pursue negotiations with the United States Bureau of Reclamation to contract for the interim rights to stored water from the federal Central Valley Project for use in the State Water Resources Development System by state water supply contractors.

10009. The director shall pursue discussions with the United States Bureau of Reclamation to permit persons and public entities which have entitlements to water from the federal Central Valley Project, to enter into legally binding contracts with any public entity which supplies water for domestic use, irrigation use, or environmental protection in this state for the transfer of federal water entitlements during times of shortage.

10011. (a) In preparing the California Water Plan, the director shall conduct at least one public hearing within the boundaries of the Sacramento-San Joaquin Delta, and shall solicit the comments of water agencies within the delta, agricultural groups representative of delta agricultural activity, environmental groups concerned with protecting delta wildlife habitat, and groups representative of those who utilize water exported from the delta.

(b) The California Water Plan shall include a discussion of various alternatives, including their advantages and disadvantages, for improving and protecting the current uses and configuration of the Sacramento-San Joaquin Delta.

(c) Subdivisions (a) and (b) shall be implemented only to the extent money is appropriated in the annual Budget Act to carry out this section.

10013. (a) The department, as a part of the preparation of the department's Bulletin 160-03, shall include in the California Water Plan a report on the development of regional and local water projects within each hydrologic region of the state, as described in the department's Bulletin 160-98, to improve water supplies to meet municipal, agricultural, and environmental water needs and minimize the need to import water.
from other hydrologic regions. The report shall include, but is not limited to, regional and local water projects that use technologies for desalting brackish groundwater and ocean water, reclaiming water for use within the community generating the water to be reclaimed, the construction of improved potable water treatment facilities so that water from sources determined to be unsuitable can be used, and the construction of dual water systems and brine lines, particularly in connection with new developments and when replacing water piping in developed or redeveloped areas.

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**SB (1341) Burton Bill**

Following the publishing of the last California Water Plan update in 1998, the Legislature asked DWR to make public all assumptions and estimates that will be used in the next update.

Sen. John Burton carried the legislation that was enacted in 2000 (SB1341 can be found [here](#)). It requires a report about the update's assumptions and estimates: this Web site.

At a minimum, the law says, the A&E Report will include information on all water categories specified by the California Water Code. Those categories can be found in the Burton Bill table.

**Text of SB 1341 (Burton Bill)**

BILL NUMBER: SB 1341

BILL TEXT

CHAPTER 720

FILED WITH SECRETARY OF STATE SEPTEMBER 27, 2000

APPROVED BY GOVERNOR SEPTEMBER 25, 2000

PASSED THE SENATE AUGUST 31, 2000

PASSED THE ASSEMBLY AUGUST 30, 2000

AMENDED IN ASSEMBLY AUGUST 7, 2000

AMENDED IN SENATE JULY 5, 2000

AMENDED IN SENATE MAY 30, 2000

AMENDED IN SENATE APRIL 24, 2000

INTRODUCED BY Senator Burton

(Coauthor: Assembly Member Machado)

JANUARY 10, 2000

An act to amend Sections 10004 and 10004.5 of, and to add Section 10004.6 to, the Water Code, relating to water.

LEGISLATIVE COUNSEL'S DIGEST

SB 1341, Burton. Water resources.

Under existing law, the Department of Water Resources operates the State Water Project and exercises specified water planning functions. Existing law requires the department to update The California Water Plan, which is a plan for the conservation, development, and use of the water resources of the state, every 5 years. This bill would require the department to update The California Water Plan on or before December 31 2003, and every 5 years thereafter. The bill would require the department to provide written notice to interested persons of meetings of a prescribed advisory committee that assists the department in updating The California Water Plan. The bill would require the department to include in the California Water Plan a discussion of the potential for alternative water pricing policies, as prescribed. The bill would require the department, as part of updating The California Water Plan, to conduct a study to determine the amount of water needed to meet the state's future needs and to recommend programs, policies, and facilities to meet those needs, as prescribed. The bill would require the department, by
January 1, 2002, and one year prior to issuing each successive update to The California Water Plan, to release a preliminary draft of the assumptions and estimates upon which the study will be based. The bill would make related findings and declarations.

THE PEOPLE OF THE STATE OF CALIFORNIA DO ENACT AS FOLLOWS:

SECTION 1. The Legislature finds and declares all of the following:

(a) A long-term, reliable supply of water is essential to protect and enhance California's natural resources and economic climate.

(b) While the Department of Water Resources has projected that Californians will experience chronic water shortages in the future, the Legislature has heard credible testimony from a number of different interest groups calling into question the accuracy of those estimates.

(c) Without credible and accurate estimates of water supply needs, it is impossible to ensure that water programs, policies, and investments are appropriate to meet all residential, commercial, industrial, agricultural, and environmental needs.

(d) CALFED's recent hearings on its draft environmental documents showed that there are widely disparate views on the role additional surface water storage should play in meeting the state's future water needs. Some argue that the state's water needs can all be met through water conservation, reuse, and other nonstructural methods. Others argue that to protect current and future uses of water, additional surface storage is essential.

(e) To reconcile these views, and to ensure the state makes appropriate investments in water programs, policies, and facilities, there needs to be a credible and objective assessment of the state's future water supply needs.

SEC. 2. Section 10004 of the Water Code is amended to read:

10004. (a) The plan for the orderly and coordinated control, protection, conservation, development, and utilization of the water resources of the state which is set forth and described in Bulletin No. 1 of the State Water Resources Board entitled "Water Resources of California," Bulletin No. 2 of the State Water Resources Board entitled, "Water Utilization and Requirements of California," and Bulletin No. 3 of the department entitled, "The California Water Plan," with any necessary amendments, supplements, and additions to the plan, shall be known as "The California Water Plan."

(b) (1) The department shall update The California Water Plan on or before December 31, 2003, and every five years thereafter. The department shall report the amendments, supplements, and additions included in the updates of The California Water Plan, together with a summary of the department's conclusions and recommendations, to the Legislature in the session in which the updated plan is issued.

(2) The department shall establish an advisory committee, comprised of representatives of agricultural and urban water suppliers, local government, business, production agriculture, and environmental interests, and other interested parties, to assist the department in the updating of The California Water Plan. The department shall consult with the advisory committee in carrying out this section. The department shall provide written notice of meetings of the advisory committee to any interested person or entity that request the notice. The meetings shall be open to the public. (3) The department shall release a preliminary draft of The California Water Plan, as updated, upon request, to interested persons and entities throughout the state for their review and comments. The department shall provide these persons and entities an opportunity to present written or oral comments on the preliminary draft. The department shall consider these comments in the preparation of the final publication of The California Water Plan, as updated.

SEC. 3. Section 10004.5 of the Water Code is amended to read:

10004.5. As part of the requirement of the department to update The California Water Plan pursuant to subdivision (b) of Section 10004, the department shall include in the plan a discussion of various
strategies, including, but not limited to, those relating to the development of new water storage facilities, water conservation, water recycling, desalination, conjunctive use, and water transfers that may be pursued in order to meet the future water needs of the state. The department shall also include a discussion of the potential for alternative water pricing policies to change current and projected uses. The department shall include in the plan a discussion of the potential advantages and disadvantages of each strategy and an identification of all federal and state permits, approvals, or entitlements that are anticipated to be required in order to implement the various components of the strategy.

SEC. 4. Section 10004.6 is added to the Water Code, to read:

10004.6. (a) As part of updating The California Water Plan every five years pursuant to subdivision (b) of Section 10004, the department shall conduct a study to determine the amount of water needed to meet the state's future needs and to recommend programs, policies, and facilities to meet those needs.

(b) The department shall consult with the advisory committee established pursuant to subdivision (b) of Section 10004 in carrying out this section.

(c) On or before January 1, 2002, and one year prior to issuing each successive update to The California Water Plan, the department shall release a preliminary draft of the assumptions and other estimates upon which the study will be based, to interested persons and entities throughout the state for their review and comments. The department shall provide these persons and entities an opportunity to present written or oral comments on the preliminary draft. The department shall consider these documents when adopting the final assumptions and estimates for the study. For the purpose of carrying out this subdivision, the department shall release, at a minimum, assumptions and other estimates relating to all of the following:

(1) Basin hydrology, including annual rainfall, estimated unimpaired stream flow, depletions, and consumptive uses.

(2) Groundwater supplies, including estimates of sustainable yield, supplies necessary to recover overdraft basins, and supplies lost due to pollution and other groundwater contaminants.

(3) Current and projected land use patterns, including the mix of residential, commercial, industrial, agricultural, and undeveloped lands.

(4) Environmental water needs, including regulatory instream flow requirements, nonregulated instream uses, and water needs by wetlands, preserves, refuges, and other managed and unmanaged natural resource lands.

(5) Current and projected population.

(6) Current and projected water use for all of the following:

(A) Interior uses in a single-family dwelling.

(B) Exterior uses in a single-family dwelling.

(C) All uses in a multifamily dwelling.

(D) Commercial uses.

(E) Industrial uses.

(F) Parks and open spaces.

(7) Evapotranspiration rates for major crop types, including estimates of evaporative losses by irrigation practice and the extent to which evaporation reduces transpiration.

(8) Current and projected adoption of urban and agricultural conservation practices.

(9) Current and projected supplies of water provided by water recycling and reuse.

(d) The department shall include a discussion of the potential for alternative water pricing policies to change current and projected water uses identified pursuant to paragraph (6) of subdivision (c).

(e) Nothing in this section requires or prohibits the department from updating any data necessary to update The California Water Plan pursuant to subdivision (b) of Section 10004.
SB (672) Machado Bill

SB 672 requires the state to include in the California Water Plan, which is prepared every five years, a report on the development of regional and local water projects, within each hydrologic region. Projects that use technologies such as desalinization, reclamation, and recycling will be included in the report. This is important because the capability of better utilizing all water sources, such as rainfall, snow melt, surface water, groundwater, ocean water or reclaimed wastewater, is a reality that can help these regions meet their own water needs without having to look elsewhere for water supplies.

BILL NUMBER: Senate Bill 672 CHAPTERED
BILL TEXT
CHAPTER 320
FILED WITH SECRETARY OF STATE SEPTEMBER 20, 2001
APPROVED BY GOVERNOR SEPTEMBER 19, 2001
PASSED THE SENATE SEPTEMBER 4, 2001
PASSED THE ASSEMBLY AUGUST 30, 2001
AMENDED IN ASSEMBLY JULY 14, 2001
AMENDED IN ASSEMBLY JULY 3, 2001
AMENDED IN ASSEMBLY JUNE 4, 2001
AMENDED IN SENATE APRIL 16, 2001
INTRODUCED BY Senator Machado
FEBRUARY 23, 2001

An act to amend Section 10620 of, and to add Section 10013 to, the Water Code, relating to water.

LEGISLATIVE COUNSEL'S DIGEST
SB 672, Machado. California Water Plan: urban water management plans.

(1) Existing law requires the Department of Water Resources to update every 5 years the plan for the orderly and coordinated control, protection, conservation, development, and use of the water resources of the state, known as the California Water Plan. This bill would require the department to include in the California Water Plan a report on the development of regional and local water projects within each hydrologic region of the state to improve water supplies to meet municipal, agricultural, and environmental water needs and minimize the need to import water from other hydrologic regions.

(2) Existing law requires every urban water supplier to prepare and adopt an urban water management plan. This bill would require an urban water supplier to describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.

THE PEOPLE OF THE STATE OF CALIFORNIA DO ENACT AS FOLLOWS:
SECTION 1. The Legislature finds and declares all of the following:
(a) The Department of Water Resources, through its contracts for delivery of water from the State Water Project, has established water entitlement objectives for approximately 4,200,000 acre feet.
(b) Municipal, agricultural, and environmental water needs have increased beyond levels anticipated in the California Water Plan and the State Water Project has not developed water projects that will yield the quantity of water established as water entitlement objectives.
(c) The health, safety, and well-being of the people of California will best be served by meeting the municipal, agricultural, and environmental water needs of each hydrologic region to the maximum extent practicable without diminishing the resources of other regions that are necessary to meet the present and future municipal, agricultural, and environmental needs of those regions, and while recognizing the
continuing need in the foreseeable future to move surplus supplies between regions in order to meet the municipal, agricultural, and environmental needs of the people of California.
(d) The health, safety, and well-being of the people of the State of California will best be served by employing current and developing water treatment and conservation technologies and by implementing the principles set forth in the Cobey-Porter Saline Water Conservation Law (Chapter 9 (commencing with Section 12945) of Part 6 of Division 6 of the Water Code) to the maximum extent practicable.

SEC. 2. Section 10013 is added to the Water Code, to read:
10013. (a) The department, as a part of the preparation of the department's Bulletin 160-03, shall include in the California Water Plan a report on the development of regional and local water projects within each hydrologic region of the state, as described in the department's Bulletin 160-98, to improve water supplies to meet municipal, agricultural, and environmental water needs and minimize the need to import water from other hydrologic regions. The report shall include, but is not limited to, regional and local water projects that use technologies for desalting brackish groundwater and ocean water, reclaiming water for use within the community generating the water to be reclaimed, the construction of improved potable water treatment facilities so that water from sources determined to be unsuitable can be used, and the construction of dual water systems and brine lines, particularly in connection with new developments and when replacing water piping in developed or redeveloped areas.

SEC. 3. Section 10620 of the Water Code is amended to read:
10620. (a) Every urban water supplier shall prepare and adopt an urban water management plan in the manner set forth in Article 3 (commencing with Section 10640).
(b) Every person that becomes an urban water supplier shall adopt an urban water management plan within one year after it has become an urban water supplier.
(c) An urban water supplier indirectly providing water shall not include planning elements in its water management plan as provided in Article 2 (commencing with Section 10630) that would be applicable to urban water suppliers or public agencies directly providing water, or to their customers, without the consent of those suppliers or public agencies.
(d) (1) An urban water supplier may satisfy the requirements of this part by participation in areawide, regional, watershed, or basinwide urban water management planning where those plans will reduce preparation costs and contribute to the achievement of conservation and efficient water use.
(2) Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.
(e) The urban water supplier may prepare the plan with its own staff, by contract, or in cooperation with other governmental agencies.
(f) An urban water supplier shall describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.

**SB (1062) Poochigian Bill**

Senate Bill 1062 by Sen. Charles Poochigian requires the Department of Water Resources (DWR) to include various strategies for meeting the state's water supply needs in its updates to the California Water Plan. It also establishes an advisory committee to help DWR update the plan.

SB 1062 describes California's need for reliable water supplies, estimates of expected population growth, and the integral role water conservation, recycling, conjunctive use, desalination, and water storage play in meeting those needs.
SB 1062 requires DWR to include a discussion of various strategies and the potential advantages and disadvantages of the strategies that may be pursued in meeting the state's water supply needs in its update of Bulletin 160. Additionally the update must identify all federal and state permits, approvals or entitlements that might be required in order to implement the strategies. This narrative will serve as the basis for future informed discussions and decisions regarding California's water plan.

Finally, SB 1062 requires DWR to establish an advisory committee, comprised of representatives of agricultural and urban water suppliers, local government, business, production agriculture, environmental interests, and other interested parties, to assist in the updating of Bulletin 160.

**BILL NUMBER: SB 1062 CHAPTERED**

**BILL TEXT**

**CHAPTER 210**

**FILED WITH SECRETARY OF STATE JULY 28, 1999**

**APPROVED BY GOVERNOR JULY 27, 1999**

**PASSED THE ASSEMBLY JULY 15, 1999**

**PASSED THE SENATE MAY 24, 1999**

**AMENDED IN SENATE APRIL 27, 1999**

**AMENDED IN SENATE APRIL 13, 1999**

**INTRODUCED BY Senator Poochigian**

**FEBRUARY 26, 1999**

An act to amend Section 10004 of, and to add Section 10004.5 to, the Water Code, relating to water.

**LEGISLATIVE COUNSEL’S DIGESTS**

B 1062, Poochigian. The California Water Plan.

Existing law requires the Department of Water Resources to update, every 5 years, The California Water Plan, which is the plan for the control, protection, conservation, development, and utilization of the water resources of the state.

This bill would require the department to establish a prescribed advisory committee to assist the department in the updating of the plan. The bill would require the department, in connection with the updating of the plan, to include in the plan a discussion of various strategies, including those strategies relating to the development of new water storage facilities, water conservation and recycling, desalination, conjunctive use, and water transfers, that may be pursued to meet the future water needs of the state, as prescribed. The bill would make related legislative findings and declarations.

**THE PEOPLE OF THE STATE OF CALIFORNIA DO ENACT AS FOLLOWS:**

**SECTION 1.** The Legislature finds and declares all of the following:

(a) A long-term, reliable supply of water is essential to protect the productivity of California’s businesses and economic climate.

(b) The Department of Finance projects that California’s population will increase to over 47 million persons by 2020, increasing the need for the development of additional safe and reliable water supplies that are critical to the health, safety, and welfare of all Californians, including the state’s future generations.

(c) Water-related infrastructure investment needs are growing rapidly as a result of a growing population and economy, environmental and public health requirements, and aging water delivery systems.

(d) The Department of Water Resources projects that Californians will experience chronic water shortages, as early as 2000, unless actions are taken to increase the amount of developed water available for use in California.
(e) Water conservation, water recycling, voluntary water transfers, conjunctive use, and desalination programs and projects will continue to be an integral part of California’s water management strategy. The review, planning, and development of new water storage facilities and the renewed operation or enlargement of existing water storage facilities should be pursued to ensure that a reliable, high quality supply of water is available to meet the current and future needs of all beneficial uses of water, including urban, agricultural, and environmental uses.

SEC. 2. Section 10004 of the Water Code is amended to read:

10004. (a) The plan for the orderly and coordinated control, protection, conservation, development, and utilization of the water resources of the state which is set forth and described in Bulletin No. 1 of the State Water Resources Board entitled "Water Resources of California," Bulletin No. 2 of the State Water Resources Board entitled, "Water Utilization and Requirements of California," and Bulletin No. 3 of the department entitled, "The California Water Plan," with any necessary amendments, supplements, and additions to the plan, shall be known as "The California Water Plan."

(b) (1) The department shall update The California Water Plan every five years. The department shall report the amendments, supplements, and additions included in the updates of The California Water Plan, together with a summary of the department’s conclusions and recommendations, to the Legislature in the session in which the updated plan is issued. (2) The department shall establish an advisory committee, comprised of representatives of agricultural and urban water suppliers, local government, business, production agriculture, and environmental interests, and other interested parties, to assist the department in the updating of The California Water Plan. The department shall consult with the advisory committee in carrying out this section.

(3) The department shall release a preliminary draft of The California Water Plan, as updated, upon request, to interested persons and entities throughout the state for their review and comments. The department shall provide these persons and entities an opportunity to present written or oral comments on the preliminary draft. The department shall consider these comments in the preparation of the final publication of The California Water Plan, as updated.

SEC. 3. Section 10004.5 is added to the Water Code, to read:

10004.5. As part of the requirement of the department to update The California Water Plan pursuant to subdivision (b) of Section 10004, the department shall include in the plan a discussion of various strategies, including, but not limited to, those relating to the development of new water storage facilities, water conservation, water recycling, desalination, conjunctive use, and water transfers that may be pursued in order to meet the future water needs of the state. The department shall include in the plan a discussion of the potential advantages and disadvantages of each strategy and an identification of all federal and state permits, approvals, or entitlements that are anticipated to be required in order to implement the various components of the strategy.

**AB (2587) Matthews Bill**

AB 2587 requires the California Department of Water Resources to consider scenarios in the California Water Plan Update that are consistent with substantial continued agricultural production in California. A key phrase in the law is that “neither the state nor the nation should be allowed to become dependent upon a net import of foreign food.” In particular, the law specifies that DWR consider scenarios under which agricultural production in California is sufficient to assure that California is a net food exporter and that the net shipments out of state are enough to cover 25 percent of “table food” use in United States plus “growth in export markets.” The 25 percent share is taken to be the traditional share from California.

Text of AB 2587 (Matthews Bill)
BILL NUMBER: AB 2587 CHAPTERED
BILL TEXT
CHAPTER 615
FILED WITH SECRETARY OF STATE SEPTEMBER 17, 2002
APPROVED BY GOVERNOR SEPTEMBER 16, 2002
PASSED THE ASSEMBLY AUGUST 28, 2002
PASSED THE SENATE AUGUST 27, 2002
AMENDED IN SENATE AUGUST 5, 2002
AMENDED IN ASSEMBLY MAY 23, 2002
AMENDED IN ASSEMBLY MAY 1, 2002
AMENDED IN ASSEMBLY APRIL 18, 2002
INTRODUCED BY Assembly Member Matthews
FEBRUARY 21, 2002
An act to add Section 411 to the Food and Agricultural Code, relating to food.

LEGISLATIVE COUNSEL’S DIGEST

AB 2587, Matthews. Food: water usage forecasts.
Existing law establishes the Department of Food and Agriculture and charges it with various duties and obligations. This bill would require the Department of Food and Agriculture to estimate food, fiber, livestock, and other farm products production, as specified, and provide that information to the Department of Water Resources for estimating related water usage, and the Chairs of the Assembly Committee on Agriculture, the Assembly Committee on Water, Parks, and Wildlife, and the Senate Committee on Agriculture and Water Resources, as specified, for inclusion in a bulletin by the Department of Water Resources estimating the state's water needs. This bill would also state the intent of the Legislature in regard to that bulletin.

THE PEOPLE OF THE STATE OF CALIFORNIA DO ENACT AS FOLLOWS:

SECTION 1. It is the intent of the Legislature that the food forecasts made by the Department of Food and Agriculture and the Department of Water Resources shall include the following considerations:
(1) Neither the state nor the nation should be allowed to become dependent upon a net import of foreign food.
(2) As the nation's population grows, California should produce enough food to supply the state and also continue to supply the historical proportion of the nation's food supply, approximately 25 percent of the nation's table food.
(3) Countries such as Japan are heavily dependent on imported food, some of which comes from California. California is also called upon to ship food to prevent famines and to protect our national interest by providing food to maintain stability elsewhere in the world. Consideration should be given to maintaining the state's ability to meet these export needs.
SEC. 2. Section 411 is added to the Food and Agricultural Code, to read:
411. (a) The Department of Food and Agriculture shall supply the Department of Water Resources with a forecast that estimates the amount of production of food, fiber, livestock, and other farm products.
(b) As part of the forecast, the Department of Food and Agriculture’s assumptions shall be based upon 20-year estimates that include, but are not limited to, the following data:
(1) Land use conversion rates and the amount of land available for agricultural production.
(2) The growing need for food, fiber, livestock and other farm products as the state's and the nation's populations grow.
(3) Implementation of irrigation technology and other on-farm water conservation measures.
(4) Advances in crop yields and production techniques.
(5) Alternate uses of crops.
(c) The department shall include an additional table in the forecast that estimates the agricultural water needs based upon food security considerations that include, at a minimum, the following:
(1) Population growth estimates.
(2) Production of farm products sufficient to feed the state's population, as well as continue to provide at least 25 percent of the nation's table food.
(3) Production necessary to meet the growth in export markets.
(d) To the extent feasible, the Department of Food and Agriculture may cooperate with the Department of Finance, the University of California, and other institutions and organizations in obtaining information for the forecasts.
(e) The Department of Food and Agriculture shall furnish the forecast to the Department of Water Resources for estimating related water usage, as well as to the Chairs of the Assembly Committee on Agriculture, the Assembly Committee on Water, Parks, and Wildlife, and the Senate Committee on Agriculture and Water Resources. The Department of Water Resources shall include this information in Bulletin 160.

Bagley-Keene Open Meeting Act
The Bagley-Keene Open Meeting Act governs notice and open meeting requirements for state bodies and is given as it appeared on January 1, 2002. The state body that meets and deliberates about the California Water Plan Update 2003 is our 70-member advisory committee.

The act declares, "It is the public policy of this state that public agencies exist to aid in the conduct of the people's business and the proceedings of public agencies be conducted openly so that the public may remain informed."
Work Plan for Meeting Legal Requirements for the California Water Plan Update 2005
# Work Plan for Meeting Legal Requirements for the California Water Plan (Water Code Sections 10004-10011)

<table>
<thead>
<tr>
<th>Water Code Section</th>
<th>Description</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>10004. (b) (1).</td>
<td>The department shall update The California Water Plan on or before December 31, 2003, and every five years thereafter.</td>
<td>Phase 1 – April 2005 Public Review Draft</td>
</tr>
<tr>
<td></td>
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<td>Phase 2 – Sept. 2005 Final Update 2005</td>
</tr>
<tr>
<td>10004. (b) (1).</td>
<td>The department shall report to the Legislature in the session in which the updated plan is issued; the amendments, supplements, and additions included in the updates of the California Water Plan, together with a summary of the department’s conclusions and recommendations.</td>
<td>Phase 1 – April 2005 on Public Review Draft</td>
</tr>
<tr>
<td>10004. (b) (2).</td>
<td>The department shall establish and consult with an advisory committee, comprised of representatives of agricultural and urban water suppliers, local government, business, production agriculture, and environmental interests, and other interested parties, to assist the department in the updating of The California Water Plan.</td>
<td>Done – Jan. 2001</td>
</tr>
<tr>
<td>10004. (b) (3).</td>
<td>The department shall release a preliminary draft of The California Water Plan, as updated, upon request, to interested persons and entities throughout the state for their review and comments. The department shall provide these persons and entities an opportunity to present written or oral comments on the preliminary draft. The department shall consider these comments in the preparation of the final publication of The California Water Plan, as updated.</td>
<td>Phase 1 – April 2005 Public Review Draft</td>
</tr>
<tr>
<td>10004.5.</td>
<td>The department shall include in the plan a discussion of various strategies, including, but not limited to, those relating to the development of new water storage facilities, water conservation, water recycling, desalination, conjunctive use, and water transfers that may be pursued in order to meet the future water needs of the state.</td>
<td>Phase 1 – April 2005 Public Review Draft</td>
</tr>
<tr>
<td>10004.5.</td>
<td>The department shall include an identification of all federal and state permits, approvals, or entitlements that are anticipated to be required in order to implement the various components of the strategy.</td>
<td>Phase 1 – April 2005 Public Review Draft</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Phases and Details</td>
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<tr>
<td>10004.5 and 10004.6. (d).</td>
<td>The department shall include a discussion of the potential for alternative water pricing policies to change current and projected water uses.</td>
<td>Phase 1 – April 2005&lt;br&gt;Public Review Draft&lt;br&gt;(Vol.2 Narrative on Economic Incentives - Loans, Grants and Water Pricing)&lt;br&gt;Phase 2 – Sept. 2005&lt;br&gt;Final Water Plan</td>
</tr>
<tr>
<td>10004.6 (a).</td>
<td>As part of updating The California Water Plan every five years, the department shall...recommend programs, policies, and facilities to meet future needs.</td>
<td>Phase 1 – April 2005&lt;br&gt;(using available information for 25 resource management strategies)&lt;br&gt;Phase 3 – next update&lt;br&gt;(using new studies)</td>
</tr>
<tr>
<td>10004.6 (a).</td>
<td>As part of updating The California Water Plan every five years, the department shall conduct a study to determine the amount of water needed to meet the state’s future needs and....</td>
<td>Phase 1 – April 2005 (using available information)&lt;br&gt;Phase 3 – Dec. 2008 (using new studies)</td>
</tr>
<tr>
<td>10004.6 (b).</td>
<td>The department shall consult with the advisory committee established pursuant to subdivision (b) of Section 10004 in carrying out this Section 10004.6 (a): determining future needs and recommending programs, policies, and programs to meet those needs.</td>
<td>Phase 1 – Jan. 2001 – April 2005&lt;br&gt;Phase 2 – Jan. 2004 - Dec. 2005&lt;br&gt;(select analytical methods, data and tools)&lt;br&gt;Phase 3 – Jan. 2006 - Dec. 2008&lt;br&gt;(conduct new studies)</td>
</tr>
<tr>
<td>10004.6. (c).</td>
<td>On or before January 1, 2002, and one year prior to issuing each successive update to The California Water Plan, the department shall release a preliminary draft of the assumptions and other estimates upon which the study will be based, to interested persons and entities throughout the state for their review and comments. The department shall provide these persons and entities an opportunity to present written or oral comments on the preliminary draft.</td>
<td>Preliminary Draft – Released Dec. 2001&lt;br&gt;Revised Draft – Released April 2005 with Public Review Draft (see attached table for details)&lt;br&gt;4 Workshops for Extended Review Forum Spring 2002</td>
</tr>
<tr>
<td>10005.1.</td>
<td>The department or, at the department's request, the California Water Commission, shall conduct a series of hearings with interested persons, organizations, local, state, and federal agencies, and representatives of the diverse geographical areas and interests of the state.</td>
<td>Phase 2 – June 2005&lt;br&gt;Conduct Public Hearings</td>
</tr>
<tr>
<td>10005.2.</td>
<td>Prior to holding the above hearings, the department shall give notice by mail of the hearings to persons and entities which have requested notice and have provided their name and address to the department.</td>
<td>Phase 1 – April 2005&lt;br&gt;For Public Review Draft&lt;br&gt;(using distribution lists for Advisory Committee, Extended Review Forum and interested public – about 2,500 people)</td>
</tr>
<tr>
<td>10011. (a)</td>
<td>In preparing the California Water Plan, the director shall conduct at least one public hearing within the boundaries of the Sacramento-San Joaquin Delta, and shall solicit the comments of water agencies within the delta, agricultural groups representative of delta agricultural activity, environmental groups concerned with protecting delta wildlife habitat, and groups representative of those who utilize water exported from the delta.</td>
<td>Phase 2 – June 2005 Conduct Public Hearing</td>
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<tr>
<td>10011. (b)</td>
<td>The California Water Plan shall include a discussion of various alternatives, including their advantages and disadvantages, for improving and protecting the current uses and configuration of the Sacramento-San Joaquin Delta.</td>
<td>Phase 1 – April 2005 Public Review Draft (using available information for 25 resource management strategies and Delta Regional Report) Phase 2 – Sept. 2005 Final Water Plan</td>
</tr>
<tr>
<td>10013.</td>
<td>The department, as a part of the preparation of the department's Bulletin 160-03, shall include in the California Water Plan a report on the development of regional and local water projects within each hydrologic region of the state, as described in the department's Bulletin 160-98, to improve water supplies to meet municipal, agricultural, and environmental water needs and minimize the need to import water from other hydrologic regions.</td>
<td>Phase 1 – April 2005 Public Review Draft (12 Regional Reports in Volume 3 based on information compiled from regional planning efforts) Phase 2 – Sept. 2005 Final Water Plan</td>
</tr>
<tr>
<td>10013.</td>
<td>This report shall include, but is not limited to, regional and local water projects that use technologies for desalting brackish groundwater and ocean water, reclaiming water for use within the community generating the water to be reclaimed, the construction of improved potable water treatment facilities so that water from sources determined to be unsuitable can be used, and the construction of dual water systems and brine lines, particularly in connection with new developments and when replacing water piping in developed or redeveloped areas.</td>
<td>Phase 1 – April 2005 Public Review Draft (using available information on 25 resource management strategies and 12 Regional Reports) Phase 2 – Sept. 2005 Final Water Plan</td>
</tr>
<tr>
<td>Water Code Section</td>
<td>Description</td>
<td>Completion Date</td>
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</tbody>
</table>
| Food and Agricultural Code Section 411 | (a) The Department of Food and Agriculture shall supply the Department of Water Resources with a forecast that estimates the amount of production of food, fiber, livestock, and other farm products.  

(e) The Department of Food and Agriculture shall furnish the forecast to the Department of Water Resources for estimating related water usage, as well as to the Chairs of the Assembly Committee on Agriculture, the Assembly Committee on Water, Parks, and Wildlife, and the Senate Committee on Agriculture and Water Resources. The Department of Water Resources shall include this information in Bulletin 160. | Phase 1 – April 2005  
Public Review Draft  
(Vol.4 - UC Davis, Agricultural Issue Center Study Report (Interim response until DWR receives CDFA food forecast))  
Phase 3 – Dec. 2008  
Complete study for Next Water Plan Update  
(assumes DWR receives CDFA food forecast) |
### Schedule for Assumptions and Estimates

**Specified In the California Water Code Section 10004.6**

**For Current Conditions**

<table>
<thead>
<tr>
<th>Water Code Section</th>
<th>Description</th>
<th>Statewide Information</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>10004.6. (c).</td>
<td>The department shall release, at a minimum, assumptions and other estimates relating to all of the following:</td>
<td><a href="http://www.waterplan10.water.ca.gov/regions">www.waterplan10.water.ca.gov/regions</a></td>
<td>Phase 1 – April 2005 Water Portfolio Data for 1998, 2000, 2001 (with some data gaps)</td>
</tr>
<tr>
<td>10004.6. (c) (1).</td>
<td>Basin hydrology:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Annual rainfall</td>
<td>329.6 maf</td>
<td>187.7 maf</td>
</tr>
<tr>
<td></td>
<td>Unimpaired runoff i</td>
<td>31.4+10.4 = 41.8 maf</td>
<td>18.9+5.9 = 24.8 maf</td>
</tr>
<tr>
<td></td>
<td>Depletions ii</td>
<td>55.6 maf</td>
<td>39.9 maf</td>
</tr>
<tr>
<td></td>
<td>Consumptive uses iii</td>
<td>25.8 maf</td>
<td>28.6 maf</td>
</tr>
<tr>
<td>10004.6. (c) (2).</td>
<td>Groundwater supplies iv:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Sustainable yield estimates U/A</td>
<td>U/A</td>
<td>U/A</td>
</tr>
<tr>
<td></td>
<td>Overdraft recovery needs vii (annual GW deficit is shown)</td>
<td>1-2 maf</td>
<td>4-5 maf</td>
</tr>
<tr>
<td></td>
<td>Supplies lost to groundwater pollution</td>
<td>U/A</td>
<td></td>
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<tr>
<td>10004.6. (c) (3).</td>
<td>Current land use patterns viii:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Residential U/A</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Commercial U/A</td>
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<tr>
<td></td>
<td>Industrial</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Agricultural viii (Irrigated crop acreage)</td>
<td>8.9 million acres</td>
<td>9.0 million acres</td>
</tr>
<tr>
<td></td>
<td>Undeveloped lands U/A</td>
<td></td>
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<tr>
<td>10004.6. (c) (4).</td>
<td>Environmental water needs:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Regulated instream flow requirements ix</td>
<td>6.9 maf</td>
<td>7.5 maf</td>
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<tr>
<td></td>
<td>Nonregulated instream flows U/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wetlands and refuge needs x</td>
<td>1.4 maf</td>
<td>1.5 maf</td>
</tr>
<tr>
<td></td>
<td>Managed natural resource lands</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Unmanaged natural resource lands U/A</td>
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<td></td>
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</tbody>
</table>

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**Workbook for Meeting Legal... Volume 4**
<table>
<thead>
<tr>
<th>Water Code Section</th>
<th>Description</th>
<th>Statewide Information</th>
<th>Regional Information on Regional Reports Webpage</th>
<th>Completion Date</th>
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<tbody>
<tr>
<td>10004.6. (c) (6).</td>
<td>Current urban water needs [5]</td>
<td></td>
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<td></td>
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<tr>
<td>10004.6. (c) (7).</td>
<td>On-farm applied water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10004.6. (c) (8)</td>
<td>Adoption of agricultural conservation practices [6]</td>
<td></td>
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<tr>
<td>10004.6. (c) (9)</td>
<td>Adoption of urban conservation practices.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10004.6. (c) (10)</td>
<td>Water supplies from water recycling and reuse (municipal) [7]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 10004.6. (c) (5).  | Current population \[4\] | 32.9 million | 34.1 million | 34.8 million | | |
| 10004.6. (c) (6).  | Current urban water needs \[5\] | Interior uses, single family dwelling | 1.7 maf | 2.1 maf | 2.0 maf | |
| 10004.6. (c) (7).  | On-farm applied water | | 0.6 maf | 0.7 maf | 0.6 maf | |
| 10004.6. (c) (8)   | Adoption of agricultural conservation practices \[6\] | | | U/A | | |
| 10004.6. (c) (9)   | Water supplies from water recycling and reuse (municipal) \[7\] | | | 11.5 maf | 8.4 maf | 5.7 maf |
For Projected Conditions

<table>
<thead>
<tr>
<th>Water Code Section</th>
<th>Description</th>
<th>Scenario 1 Current Trends</th>
<th>Scenario 2 Less Resource Intensive</th>
<th>Scenario 3 More Resource Intensive</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>10004.6. (c).</td>
<td>The department shall release, at a minimum, assumptions and other estimates relating to all of the following: Preliminary estimate of additional 2030 urban, agricultural and environmental water demands for these scenarios</td>
<td>Phase 1 – April 2005 Public Review Draft (Scenario 1 with available data) Phase 3 – Dec. 2008 (new studies for all scenarios)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10004.6. (c) (3).</td>
<td>Projected land use patterns</td>
<td>Residential</td>
<td>U/A</td>
<td></td>
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<td>Industrial</td>
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<td>Agricultural (irrigated crop acreage)</td>
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<td>9.5 million acres</td>
<td>Phase 3 – Dec. 2008 (new studies for all scenarios and responses for the next update)</td>
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<td>Projected population</td>
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<td>52.3 million</td>
<td>Phase 1 – April 2005 Public Review Draft</td>
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<td>Projected urban water needs</td>
<td>11.9 maf</td>
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<td>Phase 2 – Dec. 2005 (new studies for all scenarios and responses for the next update)</td>
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<td>Interior uses, single family dwelling</td>
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<td>Exterior uses, single family dwelling</td>
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<td>Multifamily dwelling, all uses</td>
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<td>Commercial water uses</td>
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<td>Parks &amp; open space uses</td>
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<td>10004.6. (c) (8).</td>
<td>Adoption of agricultural conservation practices.</td>
<td>All cost effective EWMPs in existing MOUs implemented by current signatories</td>
<td>All cost effective EWMPs in existing MOUs implemented by current signatories</td>
<td>All cost effective EWMPs in existing MOUs implemented by current signatories</td>
<td>Phase 2 – Dec. 2005 Update Agricultural Water Use Efficiency potential estimates using information from CALFED WUE Program &amp; other studies)</td>
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<td>Adoption of urban conservation practices.</td>
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<td>All cost effective BMPs in existing MOUs by current signatories</td>
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<td>Water supplies from water recycling and reuse (municipal)</td>
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Work Plan for Meeting Legal... Volume 4
## Table Footnotes

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<tr>
<td>From Eight River Index</td>
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<td>DWR, Statewide Water Balance Summary, Total Outflows to Salt Sink, Evaporation, and Irrecoverable Losses</td>
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<tr>
<td>DWR, Statewide Water Portfolio, Evapotranspiration of Applied Water from Agricultural, Urban and Managed Wetlands Uses, including Ag Effective Precipitation</td>
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<td>Estimates of Sustainable Yield and Supplies Lost to Groundwater Pollution are not available due to the number of variables and complexity of making such estimates</td>
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<td>DWR, Statewide Water Balance Summary, Estimates are shown for annual groundwater deficit by year. Whereas, overdraft is a long-term measure currently estimated at between 1 maf and 2 maf per year statewide (Bulletin 118-03)</td>
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<td>Land Use Patterns Statewide have not been compiled except for land in irrigated agricultural</td>
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<td>Compiled by DWR staff from Land Use Surveys and Reports from County Agricultural Commissioners</td>
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<td>DWR, Statewide Flow Diagrams, Total Required Instream Flows including flows returned to supply</td>
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<td>DWR, Statewide Water Portfolio, Managed Wetlands Applied Water</td>
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<td>Department of Finance Projections</td>
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<td>DWR, Statewide Water Portfolio. Commercial use includes both industrial and commercial uses</td>
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<td>DWR is not planning to develop information on which specific agricultural conservation practices are being used or to what level they are being adopted. Instead, DWR plans to ensure that the on-farm irrigation efficiencies, which are required to develop water use, are justifiable and agreed upon by the experts in the field. These irrigation efficiencies are an indicator of the level of water management, or conservation practices, being used.</td>
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<td>Includes reuse by all sectors.</td>
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<td>Department of Finance projections – May 2004</td>
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<td>To be developed in Phases 2 &amp; 3 as data are available</td>
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<td>To be developed in Phases 2 &amp; 3 as data are available</td>
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<tr>
<td>Developed from Water Portfolio data received from DWR Districts</td>
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Litigation

**Joint Statement on the Monterey Amendments Litigation**
By Department of Water Resources, Central Coast Water Authority, State Water Contractors, Planning and Conservation League, Plumas County Flood Control and Water Conservation District, and the Citizens’ Planning Association & Foundation of Santa Barbara County, Inc. ............................................. 929

**Summary of Significant Litigation 1998-2005**
By DWR, Office of Chief Counsel ................................................................. 933
Joint Statement on the Monterey Amendments Litigation
By Department of Water Resources, Central Coast Water Authority, State Water Contractors, Planning and Conservation League, Plumas County Flood Control and Water Conservation District, and the Citizens’ Planning Association & Foundation of Santa Barbara County, Inc.
JOINT STATEMENT ON THE MONTEREY AMENDMENTS LITIGATION
February 27, 2003

By the Department of Water Resources, the Central Coast Water Authority, the State Water Contractors, the Planning and Conservation League, the Plumas County Flood Control and Water Conservation District, and the Citizens’ Planning Association of Santa Barbara County

In 1996, the “Monterey Amendment litigation” was filed against the Department of Water Resources. (Planning and Conservation League vs. Department of Water Resources and Central Coast Water Authority) During 2001 and 2002 mediation discussions were conducted under the auspices of Judge Daniel Weinstein (Ret.). In July 2002, the discussions resulted in a statement of principles for the settlement of the litigation. The negotiators have now completed work on a detailed set of papers that embodies those principles. Those settlement papers are being reviewed by the plaintiffs (Planning and Conservation League, the Plumas County Flood Control and Water Conservation District, and the Citizens’ Planning Association of Santa Barbara County) and defendants (DWR and the Central Coast Water Authority). (State Water Project contractors who were not parties to the Monterey Amendment litigation also participated in the negotiations.)

The Monterey Amendments are amendments to the long-term water supply contracts for the SWP executed by the DWR and most of the State Water contractors in 1995 and 1996. In a 2000 ruling in this lawsuit, the Third District Court of Appeal in Sacramento held that the environmental impact report for the Monterey Amendments (“1995 EIR”) did not comply with the California Environmental Quality Act.

DWR has commenced preparing a new Environmental Impact Report (the “new EIR”) and published the Notice of Preparation for the new EIR on January 24, 2003.

This is a complex agreement. Selected key components of the settlement are summarized below:

- DWR and the SWP contractors will take actions, including adoption of new amendments to the SWP contracts, to improve and clarify disclosure of information about the delivery capability of the SWP. Contract amendments will delete the term “entitlement” and replace that term with “Table A Amount.” The amendment will not change DWR’s water delivery obligations under the SWP contracts. The amendment will also require DWR to distribute a biennial report to SWP contractors and all city, county, and regional planning agencies within the SWP project area, providing...
information as to SWP delivery capabilities, historic deliveries, and estimated deliveries under a range of hydrologic conditions.

- The parties reached agreement on the content, scope and process for the new EIR.
- DWR will act as lead agency in preparing the new EIR.
- Future negotiations for certain amendments to SWP water contracts between DWR and the SWP contractors will be conducted in public.
- DWR will issue guidelines for its review and approval of permanent water transfers.
- The Kern Water Bank will remain in local ownership and will operate as it has, but will be subject to additional restrictions on use.
- $8 million will be paid to Plumas, primarily for watershed improvements in the Feather River watershed, and for other district-related purposes, to be disbursed with input from a watershed forum composed of representatives of Plumas, local community groups, DWR, and SWP contractors.
- $5.5 million will be paid in installments to plaintiffs to implement the settlement, including watershed restoration projects, follow-up actions arising from the settlement, and technical studies.
- The State Water Project will be operated pursuant to the Monterey Amendments and new amendments pending completion of the new EIR and termination of the litigation.
- Procedural provisions of the Settlement Agreement address the relations of the parties, a process for resolving disputes, and the status of the litigation while the new EIR is being prepared and thereafter.

The Settlement Agreement and Notice of Preparation can be viewed from the DWR website links listed below:

- Settlement Agreement –Without Attachments and Exhibits
- Settlement Agreement -Attachments and Exhibits
- Settlement Agreement -Complete Document
- Notice of Preparation of EIR
Summary of Significant Litigation 1998–2005
By DWR, Office of Chief Counsel
Summary of Significant Litigation 1998-2005
By California Department of Water Resources, Office of the Chief Counsel

I. Disputes over Water Resources of Statewide Significance

A. Delta

1. Calfed Litigation: The Calfed Record of Decision issued on August 28, 2000, was challenged by environmental groups and agricultural interests in both state and federal courts. See In re Bay-Delta Programmatic Environmental Impact Report Coordinated Proceedings (Third Appellate District Court of Appeal, Consolidated Case Nos. C044267 and C044577); Don Laub v. Davis, (Fresno Superior Court No. 00CG1167), and Regional Council of Rural Counties v. State of California (Sacramento Superior Court No. 00CS01131). Three complaints filed in state courts were coordinated at the Superior Court level in Sacramento. Plaintiffs claim the CALFED Programmatic EIS/EIR violates CEQA and RCRC also alleges that the ROD is illegal under several water law theories. The state defendants won on all issues at the trial level and the two cases are pending on appeal.


2. Challenge to D-1641 Water Rights Decision: Coordinated Special Proceedings, State Water Resources Control Board Cases (3rd Dist. Court of Appeals Case No. C044714). Eleven different lawsuits were filed and coordinated in this action challenging SWRCB Water Rights Decision 1641 which implemented certain water quality objectives in the May 1995 Water Quality Control Plan. The case addressed several questions, including 1) whether D-1641 complied with CEQA; 2) whether the changes in D-1641 injured certain Delta water users; and 3) whether D-1641 was consistent with area of origin laws. The Superior Court decision largely upheld D-1641, finding that it properly decided all CEQA, area of origin, joint point of diversion, reasonable use, due process, and salmon protection issues. The court found two errors in D-1641: (1) it improperly limited the place of use for Westlands Water District, and (2) it improperly implemented the San Joaquin River flow objectives under the San Joaquin River Agreement. The case is pending on appeal.

Excluded from that appeal is one of the most difficult issues to resolve in the D-1641 Water Rights Decision: Which water users had responsibility to meet the water quality criteria? The Board’s consideration of this issue was postponed to Phase 8 of the proceedings. As an alternative to litigating this issue, the Bureau, DWR and numerous Sacramento Valley and export water interests entered into negotiations resulting in an agreement to collaborate in the development and implementation of a variety of project and actions to help meet flow-related water quality objectives, meet local water needs, and improve water supplies throughout the state. See documents posted at www.svwmp.water.ca.gov.

3. Environmental Water Account: California Farm Bureau Federation v. Mike Chrisman (Sacramento Superior Court No. 04CS00490). The Farm Bureau filed this CEQA action challenging the adoption of the Final EIS/EIR covering operation of the Environmental Water Account (EWA) through 2007, the end of the first stage of implementation of the CalFed Program. The Farm Bureau alleges the EIS/EIR does not adequately address “agricultural resources” when analyzing impacts, alternatives,
mitigation, and other issues regarding operations of the EWA. The hearing date is scheduled for October 7, 2005.

4. Term 91: El Dorado Irrigation District v. State Water Resources Control Board (Third District Court of Appeal, No. C046211). Two lawsuits were filed challenging State Water Resources Control Board Decision 2001-22, which approved an application by El Dorado Irrigation District to divert water for urban purposes. El Dorado Irrigation District and El Dorado County Water Agency challenged the imposition of Term 91, which protects SWP stored water, as part of the decision. Another lawsuit was filed by an environmental group, League to Save Sierra Lakes alleging CEQA violations. The court issued its final decision in December 2003 finding that Term 91 was improperly applied to El Dorado Irrigation District. The State Board appealed the decision and the case is pending on appeal.


6. Delta Wetlands: A private initiative to develop two Delta islands into water storage facilities was challenged in Central Delta Water Agency v. State Water Resources Control Board, 124 Cal.App.4th 245 (3rd Dist. 2004). The proposal stated that once built, purchasers of the stored water would be identified, and that likely purchasers would be users within the CVP or SWP service areas. The court held that the SWRCB water right permit issued to Delta Wetlands was invalid. The Court held that the State Constitution and Water Code require the SWRCB to determine the actual intended beneficial use of the impounded water before issuing a permit, and that a general statement of potential beneficial use with limiting conditions is insufficient. In addition, the court ruled invalid the Board’s purported delegation of authority to its Executive Officer. The California Supreme Court denied review on March 16, 2004.

7. Prospect Island: Plans for the Prospect Island Ecosystem Restoration Project were abandoned after Reclamation District 501 and others filed a lawsuit alleging failure to comply with CEQA/NEPA. The plaintiffs alleged that permanent flooding of Prospect Island could cause water to seep onto neighboring Ryer Island and prevent agricultural use of their land. See Reclamation District 501 v. U.S. Army Corps of Engineers (E.D. Cal. No. S-99-1740 FCD GGH 1999).

8. The State Water Resources Control Board’s imposition of Term 91 in water rights permits was challenged in El Dorado Irrigation District v. State Water Resources Control Board and is pending at the Third District Court of Appeal, No. C046211 (Sacramento County Superior Court, Case No. 01CS01319

**B. Central Valley Project**

1. Trinity River: In 2004, decades of dispute and litigation over the Central Valley Project’s Trinity River Division was culminated. The Trinity River Division was authorized in 1955 with the directive that the government take those measures necessary to protect the fishery and wildlife resources of the Trinity River Basin. In 1984, 20 years after full operations began, the Trinity River Basin Fish and Wildlife Management Act directed the Secretary to implement a basinwide fish and wildlife management program in order to achieve the long-term goal of restoring fish and wildlife populations in the Trinity River Basin to a level approximating that which existed immediately before the start of the construction of the Trinity River division. The 1992 Central Valley Project Improvement Act confirmed this
Congressional commitment. The Trinity River Flow Evaluation Study, completed in 1999, was a comprehensive strategy to rehabilitate the Trinity River and recreate an environment resembling the natural pre-TRD habitat. The TRFES recommended a permanent increase of flows depending on the water-year class, ranging from 368,900 AF/year in “Critically Dry” years to 815,200 AF/year in “Extremely Wet” years. Non-flow measures were also recommended. A final EIS/EIR was issued in 2000.

The EIS/EIR was challenged by Westlands Water District and other CVP contractors. In July, 2004, the Ninth Circuit Court of Appeal reversed in part the district court’s orders declaring the EIS/EIR and related orders invalid. The Ninth Circuit held that the EIS did consider a reasonable range of alternatives; that no supplemental EIS was required to discuss the NMFS’s BioOp requiring mitigation of impacts to Sacramento River temperatures and the effect of the California energy crisis; that the reasonable and prudent measure involving the mitigation of X2 movement in the Delta was invalid as a major change to the proposed action and accordingly set aside. The court stated:

The number and length of the studies on the Trinity River, including the EIS, are staggering, and bear evidence of the years of thorough scrutiny given by the federal agencies to the question of how best to rehabilitate the Trinity River fishery without unduly compromising the interests of others who have claim on Trinity River water. We acknowledge, as the district court highlighted, concerns that the federal agencies actively subverted the NEPA process, but our review of the EIS shows that the public had adequate opportunity to demand full discussion of issues of concern. Twenty years have passed since Congress passed the first major Act calling for restoration of the Trinity River and rehabilitation of its fish populations, and almost another decade has elapsed since Congress set a minimum flow level for the River to force rehabilitative action. Flow increases to the River have been under study by the Department of the Interior since 1981. Restoration of the Trinity River fishery, and the ESA-listed species that inhabit it are unlawfully long overdue...Nothing remains to prevent the full implementation of the ROD, including its complete flow plan for the Trinity River.

Westlands Water District et al. vs. United States Department of the Interior, 374 F.3d 853, 878 (9th Cir. 2004).

2. San Joaquin Drain: Longstanding disputes over the Bureau of Reclamation’s obligation to provide drainage services for lands in the San Luis Unit of the CVP were resolved by the Ninth Circuit in Firebaugh Canal Co. v. United States Department of the Interior, 203 F.3d 568 (9th Cir. 2000). The Court held that the San Luis Act required the Bureau to construct an interceptor drain and that this duty was not implicitly repealed by subsequently-enacted laws. In response, the Bureau initiated the environmental review process and in February 2004, reached an agreement with Westlands Water District regarding expanding the scope of review to include land retirement alternatives, as well as the drainage disposal alternatives. The draft EIS is scheduled to be available in the summer of 2005.

3. 1993 Allocation Dispute: Irrigators within Westlands Water District brought suit against the Bureau for allocation reductions caused by the listing of several fish species as endangered in the Delta. The Ninth Circuit found that individual water users were not qualified to assert that the United States waived sovereign immunity because they were not intended third-party beneficiaries under the contract

4. 1994 Allocation Dispute: Westlands Water District and the San Benito Water District contended that the Bureau miscalculated the allocation during the 1994 water year. The districts contended that the Bureau erred by giving the Exchange Contractors priority based on their contract which exchanged a CVP water supply for their pre-existing water rights. In *Westlands Water District v. United States Department of Interior*, 337 F.3d 1092 (9th Cir. 2003), the Ninth Circuit held that substitute water delivered to the Exchange Contractors is not “available water,” because such water is a vested priority obligation the Bureau must satisfy without including it in CVP available supply, and that accordingly, “The Westlands and San Benito contracts do not require that the Exchange contractors receive a pro-rata allocation along with the Districts; to the contrary, the contracts respect the Exchange Contractors’ priority to CVP water.” *Id.* at 1104.

5. CVPIA a. Accounting for the 800,000 acre-feet: Litigation over the Bureau’s methodology for accounting for the 800,000 acre feet to be dedicated to fish, wildlife and habitat restoration under the CVPIA was finally resolved in *Bay Institute of San Francisco v. United States*, 87 Fed. Appx.637 (9th Cir. 2004). The Ninth Circuit affirmed the district court’s holding that (1) Section 3406(b)(2) does not require Interior to calculate the cost of water actions taken pursuant to 3406(b)(2) against a hypothetical model of Project operations during the 1928-1934 drought period; (2) that Interior may not exclude from its calculation of Project yield water flows implemented in connection with Auburn Dam; (3) that Interior may not use offset/reset matrices in accounting for the use of water; and (4) that the CVPIA does not prohibit Interior from reusing water initially released for (b)(2) purposes. The Ninth Circuit held that the district court erred in concluding that Interior lacks discretion to refrain from crediting the amount of Project yield actually used for any (b)(2) purpose against the designated 800,000 acre feet of Project yield. The Court stated that “To hold otherwise would defeat the primary purpose for which the 800,000 acre feet were designated.”

b. Vernalis Standard: South Delta farmers and water agencies brought an action against the Bureau challenging the New Melones Interim Operations Plan developed under the CVPIA. The Court found, *inter alia*, that the Bureau’s decision to release water under the Plan was not arbitrary and capricious, and that plaintiffs lacked proof of actual injury. *Central Valley Water Agency v. United States*, 327 F.Supp.2d 1180 (E.D. Cal. 2004). An earlier challenge to State Water Resources Control Board Order No. 95-6 approving changes to the Bureau’s allocation of water from New Melones was dismissed for failure to join the Bureau, an indispensable party. The Bureau refused to waive sovereign immunity. *County of San Joaquin v. State Water Resources Control Board*, 54 Cal.App.4th 1144 (1997).

6. Contract Renewals a. Friant: In *Natural Resources Defense Council v. Houston*, 146 F.3d 1118 (9th Cir. 1998), cert. denied, *Lower Tule River Irr. Dist. v. Natural Resources Defense Council*, 526 U.S. 1111 (1999), the court affirmed the rescission of renewal contracts in the CVP Friant Unit where the contracts had been entered into without complying with the Endangered Species Act. Once rescinded, the contract renewals were held to be subject to NEPA under the CVPIA. On remand, the district court held that Fish & Game Code Section 5937 applies to the Bureau’s operation of the Friant Dam. *Natural Resources Defense Council v. Patterson*, 333 F.Supp.2d 906 (E.D. Cal. 2004). The court held that (1) the Court possessed jurisdiction over the claim; (2) Section 5937 required the Bureau to allow “sufficient water to pass over, around or through the dam to keep in good condition any fish that may be planted or
exist below the dam”; and that the Bureau had not released sufficient water from the dam to reestablish and maintain historic fisheries.

b. Delta-Mendota Canal: Contractors receiving water from the Delta-Mendota Canal were unsuccessful in seeking an injunction requiring the Bureau to recognize and grant the district water contract delivery priority over other CVP contractors. The court held that until the Bureau makes a final agency decision on the water district’s priority, the action is not ripe for review. *Del Puerto Water District v. U.S. Bureau of Reclamation*, 271 F.Supp.2d 1224 (E.D. Cal. 2003).

c. After the Natural Resources Defense Council submitted a letter critical of the proposed terms for CVP contract renewals, Westlands Water District sued the NRDC for a declaratory judgment that certain terms in the proposed contract were lawful. The court dismissed the complaint with prejudice on the grounds that it was not ripe for adjudication and barred by the doctrine that protects citizen petitions to the government. *Westlands Water District v. Natural Resources Defense Council*, 276 F.Supp.2d 1046 (E.D. Ca. 2003).

C. State Water Project

1. The Monterey Amendment Litigation: The 1995 amendment to the State Water Contracts resolved longstanding disputes between the urban and agricultural State Water contractors over allocation of available supply during times of shortages as well as other financial and water management issues. The Monterey Amendment (so called because of the site of the negotiations) was challenged by the Planning & Conservation League, Plumas County, and the Citizens Planning Association of Santa Barbara County. The action challenged the Environmental Impact Report, which was prepared by Central Coast Water Authority as the lead CEQA agency, and the validity of the contract amendment, particularly the transfer of Kern Water Bank lands to Kern County Water Agency. After the Superior Court ruled in favor of the Department, and the Supreme Court also ruled in the contractors’ favor on a procedural ground relating to the timeliness of the appeal of a motion to quash, *Planning & Conservation League v. Department of Water Resources*, 17 Cal.4th 264 (1998), the Third District Court of Appeal ruled that the EIR was inadequate (1) due to the designation of the Central Coast Water Agency as lead agency, rather than the Department, and (2) the EIR’s failure to adequately address potential impacts that might flow from the removal of Article 18(b) from the long-term water supply contracts. *Planning & Conservation League v. Department of Water Resources*, 83 Cal.App 4th 892 (3rd Dist. 2000). Article 18(b) provided that the Department could reduce the minimum project yield if conditions warranted. The Court noted “the commonsense notion that land use decisions are appropriately predicated in some large part on assumptions about the available water supply.” The case was remanded to Superior Court for consideration of plaintiffs’ request for an injunctive order under Public Resources Code Section 21168.9.

The parties stipulated to a stay of litigation while settlement negotiations proceeded. A settlement in principle was announced in July, 2002, and a formal settlement agreement was signed by all plaintiffs, the Department, and all State water contractors in the spring of 2003. The settlement provides for a number of actions to be taken, including the preparation of a new EIR on the Monterey Amendment. In addition, the Department and the contractors agreed to use the term “Table Amount” in lieu of entitlement and changed the state water contracts to reflect the new term. A Water Supply Reliability Report is issued biennially to provide more accurate information on the reliability of the available supply of water from the State Water Project, and a watershed protection program was initiated in Plumas County.

2. Arroyo Pasajero: The Department sought cost-sharing for flood damages incurred by landowners in the operation of the San Luis Canal, which is jointly operated by the Department and the
Bureau of Reclamation. The Court of Claims approved the Department’s claim of $2.5 million plus interest. (Court of Claims, No. 99-18C 1998).

3. Hydropower: The State Water Project’s role in electrical generation and consumption placed it in the middle of a tumultuous period in California’s history. Although the Department’s role as purchaser for net short portion of the entire State’s energy needs was separate from its role as operator of the State Water Project and therefore is not a subject of this report, there were several key judicial decisions on the role of the State Water Project in the energy field. In *Department of Water Resources v. Federal Energy Regulatory Commission*, 341 F.3d 906 (9th Cir. 2003), the court invalidated a FERC order granting authority to the Independent System Operation to control DWR’s power outages. “The question we address is whether FERC adequately responded to DWR’s position that the ISO should not control DWR outages in the same way that it controls the outages of private companies. FERC’s orders subject DWR’s generating units to the same outage control obligations that the ISO imposes on private companies selling power on the wholesale markets. These private companies, known as merchant generators, differ from a dedicated-purpose generator like DWR, a state agency whose primary mission is to store and deliver water throughout California. Creation of electrical power is essentially a by-product of DWR’s storage and distribution of water.” Id. at 910. FERC’s petition for rehearing was denied. 361 F.3d 517 (9th Cir. 2004). On remand, FERC amended the order to exclude the SWP from ISO control for outages. The ISO has requested rehearing and the decision is pending. The Ninth Circuit is reviewing a dispute over grid-wide charges, specifically whether certain PG&E transmission facilities should be integrated into grid-wide charges to all ISO customers, including DWR. *California Department of Water Resources v. Federal Energy Regulatory Commission* (9th Cir. No. 04-76131, 2005). In addition, DWR intervened in *Sacramento Municipal Utility District v. Federal Energy Regulatory Commission*, U.S. Court of Appeals, D.C. Cir. No. 04-1171, to support SMUD’s claim that it has renewal rights to its extra-high voltage contract with PG&E, which terminates in 2005. DWR contends its similar contract with PG&E also provides renewal rights.

The Department of Water Resources has been engaged in a lengthy relicensing process by which its license to operate Oroville Dam will be renewed. During this process, FERC grants annual renewals. In a case involving the Santa Ana River Hydroelectric Project, the Ninth Circuit held that annual renewal of hydropower licenses does not require state certification of compliance with the clean Water Act. *California Trout Inc. v. FERC*, 313 F.3d 1131 (9th Cir. 2002), cert. denied, 540 U.S. 818.

D. Colorado River

By the early 1990s Arizona and Nevada neared use of their full apportionments from the Colorado River, setting the stage for negotiations among California’s local agency users of Colorado River water that eventually culminated in execution of the Quantification Settlement Agreement in October 2003. To enable the QSA local agencies to reach agreement on how to reduce their use of Colorado River water, the QSA implementing legislation provided that the State take responsibility for specified QSA environmental mitigation obligations relating to the Salton Sea and for Salton Sea ecosystem restoration. The Secretary for Resources is to prepare an ecosystem restoration plan by the end of 2006. The Department of Fish and Game is to manage a restoration fund to be used for implementing fish and wildlife conservation measures in the Salton Sea and lower Colorado River ecosystems. The Department of Water Resources is to carry out specified water transfers that provide revenues for the restoration fund. Related State activities include issuance of State Water Resources Control Board water rights order for the QSA water transfers; Department of Fish and Game incidental take permits for special status species affected by the QSA water transfers, and financial arrangements for water conservation.
measures within Imperial Irrigation District. The cases listed below were brought challenging various aspects of the actions taken on the Colorado River in the Quantification Settlement Agreement and related documents. The cases have been coordinated and transferred to Sacramento Superior Court.

**Imperial Irrigation District v. All Persons, Imperial County Superior Court, Case No. ECU 01649:** This case is a contract validation action brought by Imperial Irrigation District (IID) under Section 860 of the Code of Civil Procedure to validate 13 of the QSA agreements.

**County of Imperial v. Imperial Irrigation District, Imperial County Superior Court, Case No. ECU 01650:** This petition for writ of mandate has been brought by Imperial County challenging the “water transfer project” between IID and San Diego County Water Authority (“SDCWA”). The petition alleges that the IID/SDCWA water transfer violates unspecified provisions of the Water Code and the California Environmental Quality Act.

**County of Imperial v. Metropolitan Water District, et al., Imperial County Superior Court, Case No. ECU 01656:** This action has been brought by Imperial County challenging the “QSA project.” The action is pled as a petition for writ of mandate and names Metropolitan Water District (“MWD”), IID, Coachella Valley Water District (“CVWD”), and SDCWA as respondents. Imperial County contends that these local agencies have failed to comply with unspecified provisions of the Water Code and the California Environmental Quality Act (“CEQA”) in adopting the “QSA project.”

**Protect Our Water and Environmental Rights (POWER), et al. v. Imperial Irrigation District, Imperial County Superior Court, Case No. ECU 01653:** This action has been brought by an association composed of “residents and property owners within Imperial County and elsewhere in Southern California.” This action is pled as a petition for writ of mandate and challenges the adequacy of the environmental impact report prepared by IID for the water conservation and transfer project and the habitat conservation plan under CEQA. The petition names IID as a respondent and names SDCWA, MWD, and CVWD as real parties in interest.

**Morgan, et al. v. Imperial Irrigation District, et al., Imperial County Superior Court, Case No. ECU 01646:** This action has been brought by owners or holders of land within IID’s service area and by certain residents of Imperial County. This action is pled as a petition for writ of mandate and only names IID as the respondent. The petitioners contend that IID’s October 2003 addendum to the district’s environmental impact report concerning the water conservation and transfer project fails to comply with CEQA and that CEQA requires IID to prepare a supplemental EIR.

**Morgan, et al. v. Imperial Irrigation District, Imperial County Superior Court, Case No. ECU 01643:** This action has been brought by some, but not all, of the plaintiffs who brought the previously noted Morgan CEQA action. The plaintiffs have pled this case as a reverse validation action under Section 863 of to Code of Civil Procedure. The complaint alleges a wide-ranging set of claims, including allegations that IID has failed to meet its trust obligations to district landholders, that IID assessments pursuant to the QSA violate Article XIIIID of the California Constitution (Proposition 218), that the QSA fails to comply with CEQA, that the QSA violates the Fifth Amendment prohibition against the taking of property, and that the QSA constitutes an unlawful conversion of the plaintiffs’ property.

**Morgan and Emanuelli v. Imperial Irrigation District, Imperial County Superior Court, Case No. ECU 01658:** This case is almost identical to the CEQA action filed in Morgan, et al. v. Imperial Irrigation District, Imperial County Superior Court, Case No. ECU 01646, but names San Diego County Water Authority, Coachella Valley Water District, Metropolitan Water District of Southern California, and the State of California as real parties in interest.
II. Selected Disputes over Water Resources of Primarily Regional or Local Significance

A. Monterey County

In Save Our Peninsula Committee v. Monterey County Board of Supervisors, 87 Cal.App.4th (6th Dist. 2001), an environmental group challenged an EIR for a proposed residential development of ranch property located within the Carmel River Valley. The Court of Appeal held that: (1) EIR was inadequate in its discussion of baseline water use; (2) identification of parcel, for which applicants acquired pumping rights, late in review process warranted further discussion and opportunity for public response; and (3) the EIR was inadequate in its discussion of applicants' asserted riparian right.

B. Sonoma County:

Russian & Eel Rivers: Environmental organizations successfully challenged the EIR for a project to increase Sonoma County Water Agency’s withdrawal of water from the Russian River. The Court of Appeal held that: (1) the EIR’s cumulative impacts analysis was inadequate due to failure to consider whether proposed curtailments in diversions from the Eel River to the Russian River would significantly impact project; and (2) report’s alternatives analysis was deficient. See Friends of the Eel River v. Sonoma County Water Agency, 108 Cal.App.4th 859 (2003).

C. MWDSC/San Diego

A dispute regarding Metropolitan Water District’s interpretation of its authorizing statute’s provisions on allocation of water during a time of shortage was addressed in San Diego County Water Authority v. Metropolitan Water District of Southern California, 117 Cal.App.4th 13 (1st Dist. 2004). San Diego claimed that MWD’s interpretation did not account for preferential rights San Diego claimed it earned by making substantial payments. The court rejected San Diego’s arguments, stating that “The proper forum for San Diego’s ‘changed circumstances’ argument is the Legislature, not here.” Id. At 29.

D. Santa Maria Basin adjudication

The water users in the Santa Maria Basin in the Central Coast area have been engaged in litigation to adjudicate rights to groundwater. See Santa Maria Valley Water Conservation District v. City of Santa Maria (Santa Clara Superior Court No. 1-97-CV-770214).

E. Yolo County/Putah Creek

In March of 1996 Sacramento Superior Court ruled that additional instream flows were needed for Putah Creek downstream of the Solano Diversion Dam. The judgment was appealed by the Solano parties, but a settlement, the Putah Creek Accord, was negotiated in 2000 among the parties that resolved all disputes. The settlement still provides for increased flows to Putah Creek, but includes reduced flows when Lake Berryessa is low in storage and includes a process for addressing illegal surface water diverters in Putah Creek. A Lower Putah Creek Coordinating Committee was formed made up of Yolo and Solano representatives to address Putah Creek issues such as creek habitat enhancement projects. The Committee has hired a Streamkeeper.

F. Yuba River

The State Water Resources Control Board adopted D- 1644 addressing instream flows and water rights for the portion of the Yuba River from New Bullards Bar Reservoir to the confluence of the Yuba River with the Feather River in Marysville. Yuba County Water Agency filed an appeal.
G. Los Osos Groundwater

The Los Osos Community Services District filed a lawsuit seeking determination of rights to the Los Osos Groundwater Basin. (San Luis Obispo Superior Court, 2004).

H. Central and West Basin Groundwater

A dispute over how to allocate unused storage space of an adjudicated groundwater basin was addressed in Central and West Basin Water Replenishment District v. Southern California Water Company, 109 Cal.App.4th 891 (2d Dist. 2003). The court ruled that the replenishment district had priority to manage and store water in the basin over groundwater rights holders in the basin.

I. Santa Margarita River

Longstanding disputes over the allocation and use of the Santa Margarita River were resolved in 2002. Rancho Santa Margarita v. Vail (San Diego County Superior Court No. 42850) and United States v. Fallbrook Public Utility District (S.D. Cal. No 1247-SD-T).

J. Mission Springs/Coachella Valley

A dispute among water agencies in the Coachella Valley arose over allocation of imported water, which is used to replenish groundwater which is the primary source of water in the area. See Mission Springs Water Dist. v. Desert Water Agency (Riverside/Indio No. INC 038660). The lawsuit was settled in 2004 with an agreement to work towards improving management of the groundwater recharge program, and develop a comprehensive plan for two sub-basins in the valley in order to address replenishment of groundwater in the Mission Springs area.

K. Castaic Lake Water Agency

Proposals for new developments in the Castaic Lake Water Agency in northern Los Angeles County generated a number of lawsuits, many focused on issues relating to the water supply available for such development. In County of Ventura v. County of Los Angeles (Kern County Superior Court), the EIR for the Newhall Ranch development was held to be inadequate due to its failure to address the reliability of the water supply for the project, as well as potential impacts on groundwater in Ventura County and impacts on biological resources. In Friends of the Santa Clara River v. Castaic Lake Water Agency, 123 Cal.App.4th 1 (5th Dist. 2004), the petitioners challenged the Castaic Lake Water Agency’s 2000 Urban Water Management Plan. The appellate court agreed with the petitioners’ claim that the Plan was not supported by substantial evidence due to its failure to adequately address the impacts of perchlorate contamination on the reliability of the groundwater supply. A Revised 2000 Urban Water Management Plan was subsequently adopted that addressed all of the concerns expressed by the appellate court in its decision. That Plan has not been challenged. In California Water Network v. Castaic Lake Water Agency, (Ventura County Superior Court No. CIV 215327), the petitioners challenged the adoption of a negative declaration concerning the approval of an agreement among CLWA, Semitropic Water Storage District, and the Department of Water Resources. The agreement provided for the storage of up to 24,000 acre feet of CLWA’s annual SWP deliveries in Semitropic groundwater storage basin. The challenge was rejected by the Superior Court and an appeal is pending. A similar case was filed in Sacramento Superior Court, Friends of the Santa Clara River v. Department of Water Resources (Sacramento Superior Court No. 03-CS-0028) and has been stayed pending resolution of the Ventura County case. In another case involving Castaic Lake Water Agency, a challenge was brought to the 1999 EIR for the transfer of 41,000 acre feet of SWP Table A amount from Kern County Water Agency to Castaic Lake Water Agency (Los Angeles County Superior Court No. BS 056954). Although the EIR was determined to be adequate by
the trial court, the appellate court held that the EIR was inadequate due to its reliance on the subsequently-invalidated EIR for the Monterey Amendment in Planning and Conservation League v. Department of Water Resources, 95 Cal.App.4th 1373 (3rd Dist. 2002), Friends of the Santa Clara River v. Castaic Lake Water Agency, 95 Cal.App.4th 1373 (2nd Dist. 2002). The Los Angeles County Superior Court retained jurisdiction over the action until a new EIR was prepared in compliance with CEQA. In December 2004, Castaic Lake Water Agency certified a new EIR independent of the Monterey EIR, and filed it with the Los Angeles Superior Court. Thereafter, the petitioner dismissed its action. New actions challenging the EIR, however, have been filed in the Ventura County Superior Court by California Water Impact Network and by Planning and Conservation League (Ventura County Superior Court Nos. CIV 231606 & 231588).

L. Stanislaus County/Diablo Grande

Plans for a large new destination resort and residential community in southwest Stanislaus County brought forth objections from environmental groups. In 1996, the Superior Court held that the EIR for the Diablo Grande project was inadequate due to its failure to analyze potential impacts of the future water supply after the existing five-year supply became insufficient or unavailable. Stanislaus Natural Heritage Project v. County of Stanislaus, 48 Cal.App.4th 182 (5th Dis. 1996). After the source for the permanent water supply was shifted from the original plan (SWP supply transferred from the Berrenda Mesa Water District in Kern County) to a local supply from Kern County’s Pioneer Groundwater Project, the court held that the addendum to the EIR approved by the County was not adopted in compliance with procedures required by CEQA. Protect Our Water v. County of Stanislaus, (5th Dist. No. F042089, unpublished opinion Dec. 8, 2003). In federal court, the plaintiffs were successful in their argument that the Salado Creek is a tributary of the San Joaquin River, and as such, it is a navigable water of the United States, and that the defendants were required to comply with the Clean Water Act. California Sportfishing Protection Alliance v. Diablo Grande, 209 F.Supp.2d 1059 (E.D. Cal. 2002).

III. Disputes over Interstate Water Resources

A. Klamath

Intractable disputes over water shortages and endangered species in the Klamath River Basin gave rise to litigation in a variety of settings. A mass adjudication of basin-wide water rights is pending in Oregon state court. The Ninth Circuit held that the United States Government and the Klamath Indian Tribe can be compelled to comply with the statute governing the state adjudication. (United States v. State of Oregon, 44 F.3d 758 (1994). The United States Supreme Court held that ranchers and irrigation districts have standing to bring a civil action to enforce the Endangered Species Act, including a claim that the Secretary of the Interior failed to consider the economic impact of critical habitat designation. Bennett vs. Spear, 520 U.S. 154, 117 S.Ct. 1154, 137 L.Ed. 2d 281 (1997). The ranchers’ challenge to the 1992 Biological Opinion was found to have merit: the court held that the Biological Opinion failed to address the interrelatedness or interdependence of Gerber or Clear Lake to the Klamath Project as a whole, and that the reasonable and prudent alternatives issued with regard to those reservoirs were not rationally related to the purpose of avoiding jeopardy. Bennett vs. Spear, 5 F.Supp.2d 882 (D. Oregon 1998). Ranchers challenged the Bureau’s 1997 plan of operations on a breach of contract theory; the Ninth Circuit held that the irrigators were not third-party beneficiaries to the contract between the Bureau and the dam operator (Pacificorp). Klamath Water Users Protective Association v. Patterson, 204 F2d 1206 (2000). Environmental groups challenged the Bureau’s operations as violating the Endangered Species
Act by failing to formally consult with the National Marine Fisheries Service before implementing the annual operations plan. The District Court agreed and enjoined irrigation deliveries for the 2001 season. *Pacific Coast Federation of Fishermen’s Associations v. U.S. Bureau of Reclamation* 138 F. Supp. 2d 1228. A separate attempt by the irrigators to enjoin the new 2001 operating plan was rejected. *Kandra v. United States*, 145 F.Supp. 2d 1192 (2001). Ranchers have filed a $1 billion claim with the federal Court of Claims (No. 01-591 L). The Pacific Coast Federation of Fishermen’s Associations was granted leave to intervene in that proceeding. *(United States Court of Federal Claims, No. 01-591 L, Order February 28, 2005)*. Finally, the dispute contributed to the development of the law on public records, when the United States Supreme Court ruled that the government must release copies of correspondence between certain Klamath Basin Tribes and the Department of the Interior. *Department of the Interior v. Klamath Water Users Protective Association* 532 U.S. 1 (2001).

**B. Truckee River**

Negotiations to settle disputes and litigation in accordance with the Truckee-Carson-Pyramid Lake Water Rights Settlement Act of 1990 (P.L. 101-618) have continued, leading to the development of a Truckee River Operating Agreement (TROA), which was released in October, 2003. A revised Draft EIR/EIS analyzing the draft TROA was released for public comment in August, 2004. The primary purpose of the TROA is to implement section 205(a) of P.L. 101-618, which directs the Secretary of Interior to negotiate an agreement with California and the State of Nevada to increase the operational flexibility and efficiency of certain reservoirs in the Lake Tahoe and Truckee River basins. The draft TROA would provide additional storage opportunities in existing reservoirs for future urban demands during periods of drought in the Truckee Meadows, and enhance spawning flows in the lower Truckee River for the benefit of Pyramid Lake fishes (specifically federally endangered cui-ui and threatened Lahontan cutthroat trout). In addition, the proposed TROA would satisfy existing Orr Ditch and Truckee River General Electric Decree water rights, increase recreational opportunities at Federal reservoirs, improve streamflows and fish habitat throughout the Truckee River basin, and improve water quality in the Truckee River. The draft TROA, if it becomes effective, would also trigger certain other provisions of P.L. 101-618, including the California-Nevada Interstate Allocation (section 204 of P.L. 101-618) of waters of the Lake Tahoe and Truckee River basins, and the confirmation of the Alpine Decree as part of the interstate allocation for the Carson River basin.

**C. Walker River Adjudication**

A decree was entered in 1936 allocating most of the surface water rights to the Walker River and its tributaries in California and Nevada. Disputes arose in the 1990’s over various aspects of the Decree, including the applicability of state law, water rights for federal and tribal lands, and the protection of the Lahontan Cutthroat Trout in Walker Lake. The litigation has been stayed while the parties engage in mediation to pursue a comprehensive settlement of the litigation claims and other outstanding issues in the Walker River Basin. *United States of America v. Walker River Irrigation District*; (D. C. Nev.) *In Equity Nos. C-125-A, C-125-B, and C-125-C*.

**IV. Flood Management**

In recent years public agencies have been confronted with judicial decisions that expanded previously-held concepts of liability for damages caused to private parties due to flood incidents. The line of cases, beginning with *Belair v. Riverside County Flood Control District*, 47 Cal.3d 550 (1988), set forth a standard of reasonableness for evaluating whether a public agency should be liable for damages
caused when its flood control facilities fail to protect land and property. In *Locklin v. City of Lafayette*, 7 Cal.4th 327 (1994), a set of factors was developed to judge whether a public agency’s conduct was reasonable in the face of a claim for inverse condemnation. Subsequent cases applied the *Locklin* factors: *Bunch v. Coachella Valley Water District*, 15 Cal.4th 432 (1997); *Akins v. State*, 61 Cal.App.4th 1 (3rd Dis. 1998); *Odello Brothers v. County of Monterey*, 63 Cal.App.4th 778 (6th Dis. 1998); *Arreola v. County of Monterey*, 99 Cal.App.4th 722 (2002); *Paterno v. State*, 113 Cal.App.4th 998 (3rd Dis. 2004). See also *Kevin McMahan, et al, v. State of California and Reclamation District No. 784; Yuba County Superior; Case No. 061561* (flood damages from Feather River levee failure in January 1997, pending in Superior Court). The theory, as explained in *Paterno*, is that “a landowner should not bear a disproportionate share of the harm directly caused by failure of a flood control project due to an unreasonable plan.” The Department of Water Resources responded by issuing a Flood Management White Paper. It states: “While flooding has always been an unfortunate fact of life in many parts of California, the need for adequate flood management is more critical now than ever before. California’s Central Valley flood control system is deteriorating and, in some places, literally washing away. Furthermore, the Central Valley’s growing population is pushing new housing developments and job centers into areas that are particularly vulnerable to flooding. Yet, in recent years, funding to maintain and upgrade the flood protection infrastructure has sharply declined. Compounding these challenges is a recent court ruling, *Paterno v. State of California*, that held the state liable for flood-related damages caused by a levee failure. Together, these factors have created a ticking time-bomb for flood management in California.”

### V. Other Legal Developments

#### A. Constitutional Law

Significant developments in takings law on the national level over the last decade recently entered the California water arena with several claims filed against the U.S. government. In *Tulare Lake Basin Water Storage District v. United States* (Court of Claims No. 98-101), agricultural contractors receiving water from the State Water Project claimed that delivery reductions in the early 1990’s made in order to improve Delta conditions for fish constituted a compensable taking of property in violation of the federal constitution. The Claims Court ruled in their favor and the Department of Interior did not appeal the claims court’s judgment. Although the case technically does not set a precedent for future cases, other parties have followed suit on similar theories. The Klamath River Basin irrigators have filed a claim which is pending at the Court of Claims, and the water users claiming water rights to water stored in New Melones Reservoir have also made a claim. In addition, Casitas Municipal Water District in Ventura County has filed a claim.

#### B. Water Rights Law

#### i. Surface Water

A pre-1914 water right holder is subject to the notification requirement under Fish & Game Code Section 1603. *People v. Murrison, 101 Cal.App. 4th 349 (3rd Dist. 2002)*

See discussion of Term 91 and *El Dorado Irrigation District v. State Water Resources Control Board* in Delta Section of this report.

#### ii. Groundwater

In D-1645 (2002) the State Water Resources Control Board addressed the test for determining whether or not groundwater is a “subterranean stream” and therefore subject to the permitting authority of the Board, rather than “percolating groundwater”. Water users in the San Luis Rey River Pauma basin
brought their dispute to the Board. The Board cited the presumption that all groundwater is percolating groundwater, and the party attempting to show that the groundwater was a subterranean stream had the burden of proof. The Board found evidence on both sides equally persuasive, and accordingly found that the burden of persuasion had not been met, and the basin was presumed to be percolating groundwater outside the jurisdiction of the Board.

An attempt to resolve disputes over use of groundwater in the Mojave Water Agency service area through agreement was unsuccessful due to the objections of several overlying rights holders. The California Supreme Court affirmed the rights of overlying owners. See City of Barstow v. Mojave Water Agency, 23 Cal.4th 1224 (2000).

In State of California v. Superior Court, 78 Cal.App.4th 1019 (2000), the court addressed the meaning of Water Code Section 102’s statement, that “all water within the State is the property of the people of the State.” The code section came up in the context of a dispute over an insurance policy exclusion of liability for groundwater cleanup costs at the Stringfellow Acid Pits. The court stated that the State “owns” groundwater in a regulatory, supervisory sense but not in a possessory sense: “Water Code Section 102 thus expresses the preeminent right of the people of the State to make water policy and control water usage…the State’s power is the power to control and regulate use.” Id. at 1022.

Private water companies regulated by the Public Utilities Commission cannot be sued for damages arising out of consumption of contaminated groundwater if the utility complied with federal and state drinking water standards, but can be sued for damages arising out of a failure to comply with such standards. Hartwell Corporation v. Superior Court, 27 Cal.4th 256 (2002).

A challenge to a landfill in eastern San Bernardino County was upheld due to the failure to discuss the volume of the aquifer in the EIR/EIS, with the result that agencies could not evaluate the risk of contamination. See Cadiz Land Co. v. Rail Cycle L.P., 83 Cal. App. 4th 74 (2000). The court stated that groundwater in a desert area is a rare resource under Public Resources Code Section 15125(c).

The San Mateo Superior Court ruled that the county’s decision to grant well-drilling permits is a discretionary decision subject to CEQA. Committee to Save Lake Merced v. California Gold Club of San Francisco (San Mateo Superior Court No. 416311, 2001).

C. Water Transfers & Wheeling

1. In Metropolitan Water District of Southern California v. Imperial Irrigation District, 80 Cal. App.4th 1403 (2000), MWD sought validation of its wheeling rates. MWD’s inclusion of system-wide costs in a set, predetermined rate had been the source of some controversy. The Court of Appeal held that Water Code Section 1810 et seq. did not, as a matter of law, require that plaintiff recover reasonable capital, operation, and maintenance costs incurred only with respect to the particular facilities used in the transaction (point-to-point costs), rather than including system-wide costs in calculating its rate. The court further held that the law did not mandate that plaintiff determine its rates on a case-by-case basis as transactions are proposed, instead of using a flat rate, and that MWD’s reservation of the right to interrupt service under certain conditions was valid.

2. In a challenge to a proposed water transfer from Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District to urban water users, the court held that a CEQA challenge could be brought by naming only some of the parties to the transfer agreement, if the named parties have an interest sufficient to protect the interests of those not joined. Deltakeeper v. Oakdale Irrigation District, 94 Cal.App.4th 1092 (2001).
Planning

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Addressing California’s Uncertain Water Future by Coordinating Long-Term Land Use and Water Planning: Is a Water Element in the General Plan the Next Step?

Ryan Waterman*

More people, less water: this is the widely anticipated future of the state of California. As the state’s population grows to 46 million by the year 2020, California will strive to meet water demand with a reduced water supply from the Colorado River, and struggle with the devastating impacts to the Sierra Nevada snow pack caused by global warming. Yet is California preparing for this future today? Does the law direct land-use planners on the city and county levels to work in concert with their water planning counterparts to prepare for these significant challenges? As concern over these issues has grown, recent judicial and legislative action has added new substantive requirements for land-use and water planning, as well as adding procedural requirements that ask land use and water planners to communicate with one another more consistently. In addition, both the Governor’s Office of Planning and Research (OPR) and the California Department of Water Resources (DWR) are currently updating influential reference documents for land use and water planning professionals.

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This Comment seizes this timely juncture to analyze the legal requirements for long-term land use and water planning in California. It also evaluates a proposal to add a water element as the eighth element of the general plan process for cities and counties. It concludes by offering an opinion to both the OPR and DWR on the efficacy of a water element in the general plan process as a means of improving the connection between land use and water planning.

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INTRODUCTION

One does not need a divining rod to recognize that California’s water future looks...dry.1 Increased population alone will put a strain on the state’s water resources. The Demographic Research Unit of the State of California’s Department of Finance projects the State’s population will grow by 11.3 million residents by 2020, bringing its population to 45.8 million.2 According to the most recent State Water Plan published in 1998, by the year 2020 this population growth will result in unquenched water demand of 2.4 million acre-feet (maf)3 of water in average rainfall years, and 6.2 maf in drought years.4 These are significant shortfalls. Assuming the typical single-family household uses one-half an acre-foot of water per year, and that the 2000 Census correctly gauged California’s average household size at 2.87 persons, a 2.4 maf shortfall is roughly enough water to supply 3.4 million persons, and a 6.2 maf shortfall is enough to supply 8.9 million persons.5 Of course, urban water users will not be the only ones to suffer from a water shortage—agricultural water users will suffer as well. California agricultural water users use much more water each year than urban water users—79.3% of California’s total water use compared to 20.7% for urban water uses.6

Beyond California’s population growth, two other factors may exacerbate this already challenging situation. First, similar population growth among its western neighbors is forcing California to reduce its use of Colorado River water from approximately 5.2 maf per year to the base amount of 4.4 maf per

3. An acre-foot is a standard measurement for water. One acre-foot is enough water to cover a one-acre area, one foot deep, or 325,851 gallons, or 43,560 cubic feet. See Robert J. Glennon & Peter W. Culp, The Last Green Lagoon: How and Why the Bush Administration Should Save the Colorado River Delta, 28 ECOLOGY L.Q. 903, 906 n.6 (2002); COUNTY OF RIVERSIDE GENERAL PLAN OS-4 (2003); Brydon v. E. Bay Mun. Util. Dist., 24 Cal. App. 4th 178, 182 n.1 (1994). As a general rule of thumb, practitioners now estimate that one-half acre-foot is enough water to supply the water needs of one family for a year. See Glennon & Culp, supra, at 906 n.6; COUNTY OF RIVERSIDE GENERAL PLAN OS-4 (2003).
4. STATE OF CALIFORNIA, DEPARTMENT OF WATER RESOURCES, STATE WATER PLAN ES1-2 (1998) [hereinafter STATE WATER PLAN]. This figure may exaggerate the projected water shortage. The Department of Finance’s population projection for 2020 made in 1998 for the State Water Plan was 47.5 million. Id. Today, the Department of Finance estimates that the state’s population in 2020 will be 45.8 million, 3.6% less than its 1998 projection. STATE OF CALIFORNIA, DEPARTMENT OF FINANCE, INTERIM COUNTY POPULATION PROJECTIONS (2001).
6. The California Department of Water Resources apportions water use estimates among urban, agricultural, and environmental water uses. In the 1998 State Water Plan, estimated 1995 water usage in average rain years for each category was 8.8 maf, 33.8 maf, and 36.9 maf, respectively. The Plan estimates that by 2020, water use figures in an average precipitation year for all categories will change to 12.0 maf, 31.5 maf, and 37.0 maf, respectively. See STATE WATER PLAN, supra note 4, at ES4-16.
year apportioned to it by the U.S. Supreme Court. In 2001, agreements with the United States Department of the Interior and California's fellow Colorado water users gave the State a graduated plan to cut back its usage, achieving the 0.8 maf per year reduction by 2015. The California Department of Water Resources had anticipated this reduction in its 1998 State Water Plan, but how could it have foreseen California’s latest drama? On December 31, 2002, the principal parties, including the Imperial Irrigation District (IID), the San Diego County Water Authority (San Diego), and the Metropolitan Water District of Southern California (Metropolitan), failed to reach agreement on a water transfer from IID to San Diego. The missed deadline triggered a federal government decision to cut California’s allotment of Colorado River water back to its contractual 4.4 maf per year immediately. Almost a year later, the parties signed the historic Colorado River Water Delivery Agreement (Colorado Agreement) that transfers water from IID to San Diego and Metropolitan, as well as supplying water to the endangered Salton Sea. The agreement committed California to specific, incremental steps to reduce its dependence on Colorado River water over the next fourteen years while allowing it to take more than its share, gradually easing California back to its authorized annual share of 4.4 maf. In a signing ceremony on the Hoover Dam, Secretary of the Interior Gale Norton said, “[w]ith this agreement, conflict on the river is stilled.” Secretary Norton may have spoken too soon. Both the Board of Supervisors of Imperial County and a group of farmers known as the Imperial Group have filed suit against the Colorado Agreement, alleging that the environmental review documents failed to evaluate adequately the environmental and economic harm it will do to the Imperial Valley.

Environmental changes associated with global warming may also contribute to California’s water challenges. A national group of researchers associated with the Scripps Institute for Oceanography issued a troubling study

7. The Supreme Court apportioned 4.4 maf of the Colorado River’s annual flow to California, given sufficient mainstream flows, as well as 50% of any surplus beyond the 7.5 maf apportioned to the lower basin states. Arizona v. California, 376 U.S. 340, 342 (1964); see also Glennon & Culp, supra note 3, at 912-25, 939 (discussing the formation of the statutory and case law that governs allocation of the Colorado River (known as the Law of the River) and the development of California’s claim on water from the Colorado River).

8. See Glennon & Culp, supra note 3, at 939-50 (describing in detail the complicated set of agreements between Colorado water users and the Department of the Interior to reduce California’s use of the Colorado).

9. See STATE WATER PLAN, supra note 4, at 7-56 to 7-57.


in November 2002 describing the projected effects of global warming on California’s water supply.\textsuperscript{15} Despite being labeled one of the most optimistic of a series of climate change studies, the Scripps report projected that water supplies will fall far short of future water demands.\textsuperscript{16} Although the Scripps report projects that overall precipitation levels are likely to remain constant, models show that a warming climate will reduce the Sierra Nevada snow pack (which functions as a natural reservoir).\textsuperscript{17} Currently, snow melt in the spring and summer supplies corresponding increases in water demand, but if rain rather than snow falls in the winter, rivers and streams will fill at times when demand is low. California’s water reservoirs are not designed for this pattern of precipitation.\textsuperscript{18} A study released in February 2004 by the Department of Energy’s Pacific Northwest National Laboratory (PNNL) agreed with the Scripps report, stating that global warming will “diminish the amount of water stored as snow in the Western United States by up to 70 percent in the coastal mountains over the next 50 years . . . .”\textsuperscript{19} The PNNL study’s chief modeler, L. Ruby Leung, also emphasized the model’s conservative assumptions. Echoing the findings of the Scripps report, Leung noted, “The change in the timing of the water flow is not welcome . . . [t]he rules we have now for managing dams and reservoirs and irrigation schedules cannot mitigate for the negative effects of climate change.”\textsuperscript{20}

Based on these substantial concerns, what long-term planning requirements must land use and water planners establish now to ensure a sufficient water supply for their jurisdictions in the future? Considering the significant connection between land use and water use, how integrated should those planning processes be? In 2000, one commentator noted, “planning processes for the two natural resources [land and water] remain structurally isolated. Planning for water and land uses is still conducted by different agencies, at differing times, for different periods of time, by different methodologies, pursuing objectives and goals adopted under differing considerations by different methods, agencies and constituencies.”\textsuperscript{21}

The time is ripe to analyze the legal requirements for long-term land use and water planning, as well as to make proposals for improvement. First, recent
judicial and legislative action has added significant new substantive and procedural requirements for land use and water planning, including requirements for increased communication between land use and water planners. In fact, legislative compromises struck in 2001 have caused a pause in revision of the legislative framework, creating a de facto evaluation period to analyze how the new legislation affects land use and water planning. Second, the Governor’s Office of Planning and Research (OPR) made an intriguing proposal in its 2003 General Plan Guidelines. The OPR has suggested that cities and counties include a new water element in their general plan—beyond the currently required seven elements—that focuses on water and the manner in which the city or county will plan for its acquisition, usage, and conservation. This water element would consolidate the jurisdiction’s discussion of water issues from other required elements (such as the circulation, conservation, open-space, and safety elements) in one place, making water issues easier for the public to understand. It thus makes sense to evaluate the efficacy of a proposed water element along with the regulatory schema for long-term land use and water planning.

Further, in 2003 the OPR published the 2003 General Plan Guidelines, which guides cities and counties in preparing their general plans, and the DWR began updating the State Water Plan, which describes the state’s water resources and makes future projections. This Comment aims to help both

22. Since 2000, both the California Legislature and the courts have been actively considering the requirements placed on land use and water planning. In 2001 the California Legislature passed SB 221 and SB 610, two bills that made significant changes in the requirements for land use and water planning. See discussion infra notes 69 - 72. In addition, several major court decisions have interpreted the California Environmental Quality Act (CEQA) in ways that place more requirements on land use and water planners. See Planning and Conservation League v. Dep’t of Water Resources, 83 Cal. App. 4th 892 (2000) (disapproving contract reformation between the Department of Water Resources (DWR) and its water contractors); Santa Clarita Org. for Planning the Env’t (SCOPE) v. County of Los Angeles, 106 Cal. App. 4th 715 (2003) (finding that CEQA prohibits reliance on “paper water,” specifically water from the State Water Project (SWP) that the water provider has an entitlement to but the DWR has little chance of actually serving due to lack of capacity in the SWP).

23. In a letter to the California Senate President pro Tempore John Burton (D-San Francisco) published in the Senate Daily Journal, Senator Sheila Kuehl, author of one of two bills designed to coordinate land use and water planning, wrote:

In order to allow for a reasonable period of time for SB 221 to be properly implemented, and to provide for an opportunity to assess and evaluate how it is being implemented, the author and the stakeholders of SB 221 agree that they will not introduce any legislation regarding the subject matter of this bill for a period of five years from the effective date, unless unforeseen circumstances resulting from implementation of SB 221, or the need for clarification, require it.

CAL. SENATE DAILY J. 3039 (Sept. 14, 2001). For a thorough discussion of SB 221 and its companion bills, SB 610 and AB 901, see Section II.C, infra.


25. Id. The seven required elements in the general plan are: land use, circulation, housing, conservation, open-space, noise, and safety. CAL. GOV. CODE § 65302(a)-(g) (2003). For a discussion of the general plan, see Section II.A, infra.
agencies consider the efficacy of a water element in the general plan process in order to improve the connection between land use and water planning.

The purpose of this Comment is four-fold. First, it defines the legal requirements for long-term water management planning currently required of land use and water planners by existing statutory and case law. Second, it evaluates the comprehensiveness of that regulatory schema. Third, it explores the arguments for and against adding a proposed water element to the general plan process. Fourth, it makes a recommendation to the DWR and the OPR about how each should respond to such a proposal.

The Comment proceeds as follows. Section I describes recent judicial and legislative attempts to integrate land use and water planning. Sections II and III present how land use and water planning agencies are required to conduct water management planning in the current scheme. These sections also examine points of intersection between the agencies. Section IV presents a graphic depiction of the points where water and land use planning intersect. Section V analyzes the comprehensiveness of the regulatory framework for long-term water management for land use and water planning. Section VI describes the OPR’s model water element, evaluates the general plans of three counties that have already taken steps to integrate land use and water planning in their general plans, and suggests techniques for preparing a water element for the general plan. Section VII analyzes the possible advantages and drawbacks of a water element, and the final Section concludes with the author’s recommendations and areas for further research.

I. CONVERGENCE OF LITIGATION AND LEGISLATION AT THE FAULT LINE OF LAND USE AND WATER PLANNING

Conflict over water is nothing new to the residents of California, but in the early 1990s, a battle between unusual combatants brought attention to the intersection of water and land use planning. In retrospect, the Dougherty Valley conflict between the East Bay Municipal Utility District (EBMUD) and Contra Costa County can be viewed as one of the foreshocks of a liquid earthquake—the first jolt of a movement that will significantly change the nature of land use and water planning in California.

This section provides a brief chronology of the steps already taken to integrate land use and water planning. It recounts the highlights of the past decade, beginning with the story of Dougherty Valley, and traces major legislative and judicial responses. The section also sets the stage for a more thorough analysis in Sections II and III of how these initial steps have been integrated into the baseline requirements for water and land use planning.

A. Dougherty Valley: Early Rumbles of Water Conflict

In 1991, State Assemblyman Cortese introduced AB 455. This was one of the first attempts to ensure that a legislative body could not approve
development without first determining the existence of a sufficient water supply. The bill would have added one section to the California Government Code, which would have read: “[n]o lead agency shall approve a development project unless the applicant identifies a long-term, reliable supply of water to serve the proposed project.”

Although the bill never became a law, the problem it attempted to regulate soon became front-page news.

A few days before Christmas 1992, the Contra Costa County Board of Supervisors (Contra Costa) approved the largest housing development in the county’s history. Destined for the Dougherty Valley near the communities of Dublin and San Ramon, Shapell Industries and Windemere Ranch Partners (Shapell/Windemere) proposed a development that consisted of 11,000 new homes to house roughly 30,000 people. A $4 billion project, it would be built over a thirty-year period, and when completed would use 5.4 million gallons of water per day.

But from where would the water come? The most logical supplier was the East Bay Municipal Utility District (EBMUD), water purveyor to 1.3 million East Bay residents, but the majority of the proposed Dougherty Valley development lay outside EBMUD’s service area. Ignoring EBMUD’s plea not to approve the development without securing another source of water, Contra Costa gave its go-ahead for the project by approving a general plan amendment, specific plan, and Environmental Impact Report (EIR), all listing EBMUD as the primary water provider. EBMUD responded by refusing to

28. The Dublin/San Ramon area lies approximately 34 miles almost due east of the City of San Francisco and sits in the San Ramon Valley on the inland side of the coastal foothills. Weather data for nearby Livermore, California, which sits in the same valley, has been kept since 1930 by the Western Region Climate Center. It reports that average yearly precipitation is 14.48 inches per year. Temperatures range from an average high of 57 degrees to a low of 36 degrees in January, the coldest month, to an average high of 89 degrees and a low of 54 degrees in July, the area’s hottest month. Western Region Climate Center at http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?calive+nca (last visited Jan. 21, 2004).
29. Fagan, supra note 27; Gunnison, supra note 27.
31. EAST BAY MUNICIPAL UTILITY DISTRICT, SHAPING OUR FUTURE: EAST BAY MUNICIPAL UTILITY DISTRICT ANNUAL REPORT 4 (2002).
32. Fagan, supra note 27; Haeseler, supra note 30. A City or County’s general plan is its long-term plan, which guides future development. See Section II.A, infra, for a more thorough description. A specific plan is a more detailed planning document than the general plan, and is used to implement the general plan’s policies in a subarea of the general plan area. CAL. GOV. CODE § 65450 (2003). It must be consistent with the general plan. Id. § 65454. An Environmental Impact Report, or EIR, is required by the California Environmental Quality Act (CEQA) “whenever substantial evidence supports a fair argument that a proposed project may have a significant effect on the environment. Significant effect on the environment means a substantial, or potentially substantial, adverse change in the environment.” Laurel Heights Improvement Ass’n v. Regents of Univ. of Cal., 6 Cal. 4th 1112, 1123 (1993) (citations omitted). See Section II.B, infra, for a more detailed description of CEQA’s requirements.
serve the Dougherty Valley development, citing insufficient supply to accommodate projected demand in its existing service area, let alone providing service to Doughtery Valley. It also quickly filed suit to overturn Contra Costa’s approval of the project’s EIR, alleging that Contra Costa had not complied with the California Environmental Quality Act (CEQA).  

The fight got ugly fast. Shapell/Windemere hired Barry Brokaw, former chief aide to State Senator Dan Boatwright (D-Concord), and Richie Ross, Boatwright’s former campaign manager, to generate public support for the development. They requested public records detailing EBMUD’s spending, hunting for items that might embarrass EBMUD in the press. Their findings were publicized in a column by the notorious muckrakers Matier and Ross in the *San Francisco Chronicle.* At the same time, Senator Boatwright proposed legislation to force EBMUD to supply Dougherty Valley with water by placing the Local Agency Formation Commission in a position to assess whether EBMUD was truly unable to serve the development with water. In December 1993, the legal battlefield became more complex as Contra Costa County and Shapell/Windemere filed their own suits against EBMUD, alleging that EBMUD’s policies illegally hampered development.

The battle over public opinion took a sharp turn in EBMUD’s favor when Superior Court Judge David Allen set aside the Contra Costa County’s general plan amendment and EIR, writing that the county’s approval of the project without knowing whether water is, or will be, available to serve the project fails to achieve the fundamental purpose of the California Environmental Quality Act to inform the public and responsible officials of the environmental consequences of their decisions before they are made.

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34. Phillip Matier & Andrew Ross, *Water District Spent $29,000 for Bottled Water,* S.F. *CHRON.*, June 14, 1993, at A13 (the most widely quoted item from this publicity campaign was $29,075 spent on bottled water. EBMUD later explained that the water was purchased to supply workers at a wastewater plant where the water lines had broken).
35. Tupper Hull, *Battle Lines Drawn in Contra Costa Over Water,* S.F. *CHRON.*, July 7, 1993, at A1. Every County in California has a Local Agency Formation Commission, or LAFCO. *CAL. GOV. CODE* § 56325. Generally, a LAFCO is composed of two representatives from the County Board of Supervisors, two representatives chosen from among the city council members of the cities within the County, two representatives chosen from among the officers of the independent special districts in the County, and one representative from the general public. *Id.* Some counties have LAFCO memberships defined by statute, such as Los Angeles, Sacramento, Santa Clara, and San Diego counties. *See Id.* §§ 56325-28. LAFCOs are responsible for determining whether an unincorporated area can be incorporated into an existing city, or whether a new city should be incorporated altogether. *Id.* § 56375. They determine whether a special service district should be created to provide public services (such as water, sewer, transit, or numerous other services), or whether an existing special service district should be disbanded because it is no longer useful. *Id.* LAFCOs also serve an important informational function and are charged with studying and inventorying the abilities of local governments and service providers. *Id.* § 56378.
In a later decision in a suit brought separately by environmentalists, Judge Allen also ruled that Shapell/Windemere had not adequately addressed the source of wastewater and sewage treatment facilities.  

As the appeals to Judge Allen’s decision began, a hotly contested election for seats on the EBMUD Board of Directors raged. In the previous 1990 election, citizens elected environmentally-oriented candidates to four of the Board’s seven positions. In the 1994 election, however, the Building Industry Association of Northern California spent $150,000 in mailings to defeat two of the environmentally-oriented EBMUD Board incumbents. The 1994 election reconstituted EBMUD’s Board, returning only two of the four environmentalists. Instead of a four to three pro-environmental majority, the Board now had what one observer described as a “five-to-two pragmatic majority . . . interested in developing new sources of water, including tapping the American River,” a project that the environmental board members opposed.

After the election, the parties reached a settlement agreement before the appellate court issued a ruling. Shapell/Windemere agreed to seek other sources of water and drop its suit against EBMUD, while EBMUD agreed to serve Dougherty Valley if Shapell/Windemere’s “best efforts” to find another source of water failed. The developers would have to pay for any conservation programs if EBMUD ran short of water, and drought conditions would stop additional development completely. The reconstituted EBMUD Board voted 4-3 to approve the settlement, as did the Contra Costa Board of Supervisors with a vote of 3-2.

In the end, Shapell/Windemere found water for the Dougherty Valley development in a remote rural corner of Kern County, available for $7 million, from the Berrenda Mesa Water District. Shapell/Windemere made the deal in 1994, buying permanent rights to 7,000 acre-feet, enough to supply

40. Id.
41. Id.
42. Id. (quotations omitted).
45. Hallissy, supra note 43.
46. Dale Kasler, Private Water Sales Are Paving Way For Growth, SACRAMENTO BEE, Sept. 22, 2002. It may seem odd that the Dougherty Valley development near the Bay Area would be buying water from a water district in Kern County, available for $7 million, from the Berrenda Mesa Water District. Shapell/Windemere made the deal in 1994, buying permanent rights to 7,000 acre-feet, enough to supply

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approximately 14,000 homes. Although litigation challenging the Dougherty Valley development has continued, Shapell/Windemere had constructed 964 homes and 252 apartment units by March 2003. Yet the Dougherty Valley conflict prompted both the legislature and the courts to look more closely at the intersection of land use and water planning.

B. Brief Summary of Legislative and Judicial Action after Dougherty Valley

The first response to prevent a future Dougherty Valley-type conflict was legislative. Sponsored by Senator Costa (D-Fresno) and passed in 1995, Senate Bill 901 attempted to ensure that cities and counties collaborate with water agencies early in the planning process. The bill required cities and counties to obtain a water supply assessment from the water supplier for large projects requiring a general plan amendment or specific plan. Cities and counties also had to include this information in the EIR prepared for the project. While the land use jurisdiction retained the ultimate decision-making power to approve or reject the proposed development regardless of the information provided by the water supplier, SB 901 was one of the first laws that required land use and water agencies to communicate with each other.

Unfortunately, jurisdictions found SB 901 easy to avoid. A study by EBMUD in 2000 found that of the 119 large-scale developments subject to SB 901 between 1996 and 2000, only 2% complied with all five of its requirements. In fact, 24% failed to comply with the law at all, 36% only complied with the first provision by identifying the water supply to be relied upon, and 38% identified the water supply and at least one of SB 901’s four other elements: 1) proving water supplies, 2) assessing drought conditions, 3) analyzing third-party impacts, and 4) developing additional supplies. In the opinion of one observer, SB 901 was “more often than not honored only in the breach” of its provisions. These revelations spurred further legislative attempts to close the loopholes in SB 901, but the next part of the story takes place in the courts.

As cities and counties were implementing SB 901 to questionable extent, the courts began ruling on challenges to development based upon the California Planning

47. Id.
50. SB 901 amended Section 65302 and added Section 65302.2 to the Government Code, added Section 21151.9 to the Public Resources Code, and added Part 2.10 (commencing with Section 10910) to Division 6 of the Water Code. See http://info.sen.ca.gov/cgi-bin/postquery?bill_number=sb_901&sess=9596&house=B&site=sen for the full text of the bill.
52. Id.
Environmental Quality Act (CEQA). In Stanislaus Natural Heritage Project v. County of Stanislaus, 48 Cal. App. 4th 182 (1996), the Fifth District Court of Appeal invalidated Stanislaus County’s first tier EIR for a specific plan detailing a 29,500 acre residential and resort development because the County did not know what water supply source the development would use after the first five years of the multi-year project. Many commentators interpreted this decision as a directive to land use planners not to get ahead of the planning efforts of their water supply counterparts. Although Stanislaus Natural Heritage Project was grounded in CEQA and not legal changes made by SB 901, it sounded the same theme—namely that land use planners must get some assurance about water supply from their water planning cohorts before project approval.

The next landmark appellate decision, coming this time from the Third District Court of Appeal, was County of Amador v. El Dorado County Water Agency, 76 Cal. App. 4th 931 (1999). In County of Amador, the court invalidated the El Dorado County Water Agency’s (EDCWA) certification of an EIR approving a water supply project designed to serve future growth in El Dorado County. The court found the EIR fundamentally flawed because “[t]he need for new water supplies was predicated on [growth] projections contained in a draft, unadopted general plan.” The court concluded that allowing EDCWA to justify its new water supply project with a draft, unadopted general plan would create a circular process that would defeat CEQA’s intent. If a water supply project could be built to supply growth projections in a draft general plan, then there would be no reason to disapprove the draft general plan because a water supply would be available to serve it. In the court’s opinion, this self-justifying loop would prevent the land use agency from ever seriously contemplating the effects of new development called for in the general plan. Although the court limited its holding to a water project based on a draft general plan, it raised a new question: can long-term water planning look beyond the typically ten to fifteen year time horizon of the general plan for the jurisdiction it seeks to serve? If not, this result could be seen as conflicting with the holding of Stanislaus Natural Heritage Project, unless one understands the land use and water planning process as an integrated whole that should never get out of balance.

While Stanislaus Natural Heritage Project took issue with the County’s lack of discussion of water supply, Planning and Conservation League v.

54. Id. at 195. For a brief explanation of EIR tiering, see infra note 166.
56. Id. at 941.
57. Id.
58. Id. at 950-51.
59. Id. at 950.
60. Id.
Department of Water Resources, 83 Cal. App. 4th 892 (2000), highlighted another problem—the possibility of land use agencies relying on “paper water” to approve development. In Planning and Conservation League, the court invalidated an EIR studying the effects of an agreement (known as the Monterey Agreement) that modified the contracts between the Department of Water Resources (DWR), and the urban and rural water contractors with entitlements to water from the State Water Project (SWP). In its original design, the DWR intended the SWP to deliver 4.2 million acre-feet (maf) of water per year, but only half of the intended waterworks were actually built, creating only half the anticipated capacity. Despite the gap between what the DWR designed and what was built, the water contractors based their entitlements to SWP water on the full build-out capacity of the SWP, creating entitlements to “paper water”—water that could not be delivered by the DWR because the SWP had never been finished. The DWR’s contracts with the water contractors addressed the problem of paper water in article 18, subdivision (b) of the contracts, which provided for a pro rata reduction of all contractors’ entitlements should the DWR determine that the SWP would never be completed.

The most important change wrought by the Monterey Agreement was the elimination of article 18, subdivision (b), which assured that water contractors’ entitlements would never be reduced. The court invalidated the Monterey Agreement’s EIR because it failed to consider the effect of removing article 18, subdivision (b), on land use decisions. The court noted, “[t]here is certainly the possibility that local decision makers are seduced by contractual entitlements and approve projects dependent on water worth little more than a wish and a prayer.”

By year-end 2001, the legislature once again approved a law designed to integrate land use and water planning. Senator Costa sponsored SB 610, a revision and extension of SB 901. SB 610 expanded on two existing water

61. The agreement was dubbed the Monterey Agreement because the negotiations that created it were held in Monterey, California. 83 Cal. App. 4th at 901.
62. Id. at 901-02. A more detailed explanation of the Department of Water Resources and the State Water Project it operates is included in Section III.A.1, infra.
63. Id. at 898-99.
64. Id. at 914.
65. Id. at 899-900.
66. Id. at 908.
67. Id. at 915.
68. Id.
69. This is not to suggest that the intervening six-year period between the passage of SB 901 and the next series of legislative efforts to tighten the links between water and land use planning were void of legislative activity. In fact, lobbyists from the East Bay Municipal Utility District were especially important in convincing state water planners, building industry policymakers and local government representatives that water supply planning continued to be a serious issue in need of more comprehensive legislation. Interview with Randele Kanouse, Manager of Intergovernmental Affairs, East Bay Municipal Utility District, in Sacramento, Cal. (Dec. 19, 2002).
planning measures. First, it revised the substantive and procedural requirements of the Urban Water Management Plan Act (UWMP), which requires water agencies to produce a report on their water supplies and the projected demands on those supplies. Second, it strengthened the water supply assessment provision first introduced by SB 901. Senator Sheila Kuehl (D-Los Angeles) sponsored SB 610’s companion bill, SB 221, which introduced a new water supply verification requirement at the tentative subdivision map approval stage. Under SB 221, approval of a large residential subdivision requires substantial evidence that a sufficient water supply is available to serve the subdivision’s existing and planned water uses. Finally, Assemblywoman Lynn Daucher (R-Anaheim) sponsored AB 901, which required that the water agency’s UWMP include “information . . . relating to the quality of existing sources of water . . . and the manner in which water quality affects water management strategies and supply reliability.”

The courts have made the most recent push to integrate land use and water planning. In *Santa Clarita Organization for Planning the Environment (SCOPE) v. County of Los Angeles*, 106 Cal. App. 4th 715 (2003), the Second District Court of Appeal returned to the issue of “paper water,” first introduced in *Planning and Conservation League*. At issue in *SCOPE* was the County of Los Angeles’ approval of an EIR studying the impacts of a development in the Santa Clarita Valley involving 2,545 housing units, 180,000 square feet of commercial retail, and 46 acres of community facilities. The court opened its opinion with a clear statement: “An environmental impact report for a housing development must contain a thorough analysis that reasonably informs the reader of the amount of water available.” The court found Los Angeles County’s EIR deficient because it relied on SWP entitlements to show a sufficient water supply. In vacating the County’s approval of the EIR, the court concluded that,

the EIR fails to undertake an adequate analysis of how much water the SWP can actually deliver . . . . Without such information, the general public and its responsible officials cannot make an informed decision on whether to approve the project. The County’s approval of the West Creek EIR is not supported by substantial evidence.

Interestingly, the *SCOPE* court was not impressed by the EIR’s discussion of the water supply verification requirement put into place by SB 221. The EIR claimed that because each subdivision included in the West Creek development would have to obtain a water supply verification before its tentative subdivision map could be approved, the development itself “would not result in an

70. See Section II.C for a detailed description of SB 610’s provisions.
71. For a more detailed description of SB 610 and 221’s requirements, see Section II.C, infra.
73. 106 Cal. App. 4th at 718.
74. Id. at 717.
75. Id. at 724.
unavoidable significant cumulative impact on Santa Clarita Valley water resources.” Despite this later check on incremental subdivision development, the court still insisted that CEQA requires an evaluation of a comprehensive project’s water supply in the first-tier EIR. In fact, the court ignored the fact that this subsequent water supply verification would take place in the County’s discussion of the information to be included in the EIR.

II. LAND USE PLANNING LAW: WATER PLANNING REQUIREMENTS IN LAND USE DECISION-MAKING

Understanding the legal requirements linking land use and water planning is critical not only to evaluating how well prepared California is to manage its water challenges, but also for considering the potential benefits and challenges of measures to improve the connections between the two disciplines. This section looks at water management planning required of land use planning agencies by California statutory and case law.

“Water management planning,” as used in this Comment, refers to the interconnected issues of: water supply (including water conservation), water quality, wastewater treatment and disposal, flood management, watershed management, and stormwater management. While evaluating the required planning duties of both land use and water planning agencies, this Comment notes the statutory and judicial requirements placed on the agencies for each of these areas. This is important because the proposed water element described in Section VI suggests that all of these areas should be included in such an element.

This section proceeds as follows. First, it evaluates the water planning requirements inherent in the general plan process. Second, it describes several important judicial interpretations of the California Environmental Quality Act (CEQA), which have added to the requirements imposed on land use planning agencies in the general plan process. Third, it includes several recent legislative actions—most notably SB 610 and SB 221—that have attempted to link water management planning more closely with land use planning.77

76. Id. at 719.
77. As mentioned earlier, several important pieces of legislation took effect on Jan. 1, 2002, which raised the level of detail required for water planning and more closely linked the land use and water planning processes. These bills did so by amending and adding provisions to existing laws governing city and county land use planning, and water district planning. For example, SB 610 expanded and extended the requirements initially introduced by SB 901 in 1995. Where appropriate, the author has included textual references and footnotes identifying the changes made by these important bills to the general plan and UWMP statutory framework. For specific discussion of SB 221 and 610 and a thoughtful analysis of potential interpretive issues, see Zinn, supra note 53.
A. The General Plan Requirement and Water Management

Each city or county must prepare “a comprehensive, long term general plan,” which functions as the constitution of the city or county. There is no specific requirement for how far into the future the general plan must project, or how frequently it must be updated, although it should be reviewed regularly and revised as new information becomes available. Many jurisdictions use a planning time frame of fifteen to twenty years for their general plan, although there is no standard planning horizon. The statutory framework for the general plan requires treatment of seven mandatory elements: land use, circulation, housing, conservation, open-space, noise, and safety. These elements must be internally consistent with one another, creating an integrated, usable document.

General plan requirements include both informational requirements (specific discussion of particular issues related to planning, i.e. the location of floodplains within the jurisdiction), and procedural requirements (procedures that planning agencies must follow while preparing a general plan). These requirements are not segregated in the statute, but it is helpful to consider them in turn for several reasons. First, planning problems may arise from insufficient information being included in a general plan, from inadequate communication between agencies during the planning process, or from a combination of the two. Segregating the informational and procedural requirements as they currently stand presents a clearer picture of where possible weaknesses may lie. For example, land use planning agencies must incorporate large amounts of information into general plans, and it is helpful to examine what information land use agencies are required to provide on their own, and what information they are required to obtain through consultation with other agencies. Any requirement that forces one agency to consult with another creates an opportunity to build relationships, develop more sophisticated analyses, and to treat the subject more comprehensively. However, such consultation also risks miscommunication, dysfunctional processes, and cursory, arms-length discussions.

79. Each city and county must adopt a general plan “for the physical development of the county or city, and any land outside its boundaries that bears relation to its planning.” CAL. GOV. CODE § 65300. The general plan has been called a city or county’s Constitution for future development. See OPR GUIDELINES, supra note 24, at 10.
80. The exception to this general statement is the housing element, which must be updated every five years. See CAL. GOV. CODE § 65588. In addition, the Office of Planning and Research is required to notify a city or county if it has not updated its general plan in eight years, and the California Attorney General if city or county has not updated its general plan in ten years. CAL. GOV. CODE § 65040.5(a)-(b).
81. CAL. GOV. CODE § 65103(a).
82. OPR GUIDELINES, supra note 24, at 14 (noting that “the local jurisdiction may choose a time horizon that serves its particular needs.”).
83. CAL. GOV. CODE § 65302(a)-(g).
84. Id. § 65300.5.
exchanges. By isolating the substantive and procedural aspects of the general plan process, it may be possible to see more clearly where improvements can be made. Second, segregating the analysis in this way also furthers this Comment’s ultimate goal of evaluating what a proposed water element may add to the planning process. By clearly presenting the informational baseline requirements for general plans, it will be easier to review the benefits and drawbacks of the proposed water element.

I. Informational Requirements in the General Plan

California Government Code section 65302 describes the elements of a general plan and the minimum subject matter that the plan must address within each element, although jurisdictions may add more detail. Recognizing the vast differences among cities and counties within the state, section 65301(c) directs that each of the elements should be addressed in general plans “to the extent that the subject of the element exists in the planning area. The degree of specificity and level of detail of the discussion of each such element shall reflect local conditions and circumstances.”

Of the seven mandatory elements that cities and counties must cover in their general plans, some degree of water management information addressing water supply, water quality, wastewater treatment and disposal, flood management, watersheds management, and/or stormwater management is required in five of them: land use, circulation, conservation, open-space, and safety.

**Land Use Element:** The land use element designates “the proposed general distribution and general location and extent of uses of the land . . . .” It presents the guiding principles that govern the approval of future land use within the jurisdiction. For example, the Riverside County General Plan, adopted in October 2003, provides a Land Use Element with three sections: (1) a background section that describes the natural and urban setting of the county; (2) a statistical summary detailing land usage and buildout capacities; and (3) a section with land use policies that direct future development.

Although some jurisdictions have added more requirements, the only statutorily required water management content that planning agencies must include in the land use element is to “identify areas covered by the plan which are subject to flooding . . . .” There are no explicit statements in the Government Code—beyond description of flood plains—about how water management planning should be integrated into the land use decision-making

85. Id. § 65303.
86. Id. § 65301(c).
87. Id. § 65302(a).
89. CAL. GOV. CODE § 65302(a).
Conspicuously absent in the land use element are requirements to include consideration of water supply and water quality issues created by new development. In fairness, many of the other required elements refer back to and must be consistent with the land use element, thereby imputing the other elements’ water management planning requirements back to the land use element. Yet, it is the approved pattern of land use that will dictate the demands on an area’s water resources. The almost complete absence of water management requirements in the land use element is an initial indication of the disconnect between the land use and water planning functions.

**Circulation Element:** The circulation element requires an accounting of “the general location and extent of existing and proposed . . . local public utilities and facilities, all correlated with the land use element of the plan.” At a minimum, this element requires description of existing and proposed water infrastructure, as well as wastewater treatment and disposal infrastructure, overlaid onto the land use map. While this information is important, it is only a descriptive requirement that generally has no normative effect on development. The exception is land reserved for water-related uses, such as runoff basins, canals, or reservoirs, which must be described in a jurisdiction’s open space element, as discussed, *infra*.

**Conservation Element:** The conservation element is one of two elements in which water management planning is most clearly intended by the statutory language, yet its provisions are so broadly construed that they could justify almost any interpretation a jurisdiction might supply. The conservation element is for “the conservation, development, and utilization of natural resources including water and its hydraulic force, forests, soils, rivers and other waters, harbors, fisheries, wildlife, minerals, and other natural resources.” Further, it “shall consider the effect of development within the jurisdiction, as described in the land use element, on natural resources located on public lands . . . .” Finally, if the water agency that supplies water to the development has provided water supply and demand information to the jurisdiction, then the jurisdiction shall coordinate with the water agency by discussing the information. Yet nothing in the law goes further to define what kind of analysis these broad statements require.

In the absence of clarity, one can find guidance from the Office of Planning and Research (OPR), which is charged with aiding cities and counties

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90. *Id.*
91. *Id.* § 65302(b).
92. *Id.* § 65302(d).
93. *Id.* (emphasis added) (depending on the percentage of privately-owned land within the jurisdiction, this could be a substantial limitation on the conservation element’s analysis of the impact of development proposed in the land use element).
94. *Id.*
in complying with their general plan requirement.\textsuperscript{95} According to the OPR, the conservation element has not been “the specific subject of either court decisions or legal opinions of the California Attorney General.”\textsuperscript{96} The OPR’s 2003 General Plan Guidelines, however, assume that the conservation element is the proper place to inventory water resources (rivers, lakes, streams, etc.), define watershed boundaries, assess water supply and water quality, and project water demand, supply, and quality.\textsuperscript{97}

The law creates no affirmative obligation to provide this information, however. Section 65302(d) only notes that the conservation element may also cover the following: (1) The reclamation of land and waters. (2) Prevention and control of the pollution of streams and other waters. (3) Regulation of the use of land in stream channels . . . . (5) Protection of watersheds. . . . [and] (7) Flood control.\textsuperscript{98}

In fact, many counties do detail their water supply, water quality, and watershed management plans in the conservation element.\textsuperscript{99} Yet the substance of those discussions is left almost entirely up to the jurisdiction preparing the plan.

\textbf{Open Space Element:} The open space element is the second place where water management planning is clearly contemplated in the law. Open space land is defined as “any parcel or area of land or water that is essentially unimproved and devoted to an open-space use . . . .”\textsuperscript{100} This definition controls the breadth of the open space element. The element requires a description of lands designated as open space lands for the purposes of

\begin{itemize}
    \item [1] preservation of natural resources including, but not limited to . . . habitat for fish and wildlife . . . rivers, streams, bays and estuaries . . . and coastal beaches, lakeshores, banks of rivers and streams, and watershed lands,
    \item [2] managed production of natural resources, including but not limited to . . . areas required for recharge of ground water basins; bays, estuaries, marshes, rivers and streams which are important for the management of commercial fisheries . . . ,
    \item [3] outdoor recreation, including but not limited to, areas particularly suited for park and recreation purposes, including access to lakeshores, beaches, and rivers and streams,
    \item [and 4] “public health and safety, including, but not limited to, areas which require special management or regulation because of hazardous or special
\end{itemize}
conditions such as . . . floodplains, watersheds . . . [and] areas required for the protection of water quality and water reservoirs . . . .

Unless land is defined as “essentially unimproved and dedicated to an open-space use,” the aforementioned requirements do not apply.

To its credit, the open space element lists its required water management subject matter in finer detail than any other element, requiring discussion about water supply (recharge of groundwater basins), watershed management, flood management, and water quality (areas required for the protection of water quality and water reservoirs). While some of the open space element’s requirements may overlap with the conservation element’s requirements, the open space element’s specificity is greater than that of the conservation element. In some cases, jurisdictions have combined the conservation and open space elements into a single element.

Safety Element: Finally, the safety element requires mapping of hazardous zones for flood, dam failure, tsunami, and slope instability, as well as planning to avoid catastrophes and to address them if they ever occur.

In summary, general plans’ informational requirements for water management planning are minimal and largely avoidable. Lack of specificity in some places, most notably the land use and conservation elements, robs general plan requirements of some of the impact they would otherwise have. The requirements leave much interpretive room to the cities and counties preparing the general plans, which may allow them to avoid, or supply insufficient discussions of, important water management planning issues.

2. Process Requirements in Preparation of the General Plan

Land use planning agencies must often gather information from outside sources while preparing general plans. In addition, the Government Code mandates that the general plan development process be a public one, and many different groups must have the opportunity to contribute and comment. At minimum, before adopting or amending a general plan, the “legislative body must hold at least one public meeting.” Specifically, the Legislature has declared: “it is vital that there be close coordination and consultation between California’s water supply agencies and California’s land use approval agencies

101. Id. §§ 65302(e), 65560.
102. Id. § 65560.
103. For example, the Riverside County General Plan integrates both the open space and conservation elements into a single Multipurpose Open Space Element. COUNTY OF RIVERSIDE GENERAL PLAN, MULTIPURPOSE OPEN SPACE ELEMENT, ch. 5 (2003).
104. CAL. GOV. CODE § 65302(g).
105. Id. § 65351 (requiring that the planning agency “provide opportunities for the involvement of citizens, public agencies, public utility companies, and civic, education, and other community groups, through public hearings and any other means the city or county deems appropriate”).
106. Id. § 65355.
to ensure that proper water supply planning occurs in order to accommodate projects that will result in increased demands on water supplies.”

In order to accomplish this goal, cities and counties must consult and coordinate with water planning agencies in several respects. First, the conservation element requires that the land use planning agency work together with the water management agency (or agencies) to develop the conservation element. Second, the land use planning agency must utilize the Urban Water Management Plan (UWMP) of the relevant water planning agency (or agencies) as a source document for the adoption or revision of the general plan, if the UWMP has been submitted to the land use agency.

Third, before the ratification of a general plan, the land use planning agency must send a copy of the draft general plan to any public water system . . . with 3,000 or more service connections, that serves water to customers within the area covered by the proposal. The public water system shall have at least 45 days to comment on the proposed plan . . . and to provide the planning agency with information set forth in Section 65352.5.

In turn, the water agency receiving the land use planning agency’s draft general plan must respond within forty-five days with any comments it has on the proposed plan, as well as providing the following information to the land use agency, as required by section 65352.5:

1) current Urban Water Management Plan
2) current capital improvement plan
3) description of the total water supply available to the water agency
4) description of surface water available

107. Id. § 65352.5(a). Despite the apparent good intent of this statement, the author finds this phrasing awkward and somewhat difficult. First, it seems to imply that proper water supply planning occurs only when it results in projects that increase demands on water supplies. Although the implication was likely unintended, it seems to preclude water supply planning for projects that do not increase demands on water supply (for instance, a project that pays for water conservation in neighboring areas in order to mitigate the impact on the water district bound to serve it). Second, although the finding strongly states that close coordination and consultation between land use and water agencies is vital, the law that implements it goes on to provide for an exchange of documents at the end, or near the end, of the respective land and water development processes—the draft general plan on the land use side, and the most recent Urban Water Management Plan on the water side. More appropriate phrasing might change Section 65352 to read: “it is vital that there be close coordination and consultation between California’s water supply agencies and California’s land use approval agencies. Proper water supply and land use planning occurs when each planning process includes its sister discipline from the earliest stages.”

108. The statute requires: “That portion of the conservation element including waters shall be developed in coordination with any countywide water agency and with all district and city agencies that have developed, served, controlled or conserved water for any purpose for the county or city for which the plan is prepared. Coordination shall include the discussion and evaluation of any water supply and demand information described in Section 65352.5, if that information has been submitted by the water agency to the city or county.” Id. § 65302(d).

109. Id. § 65302.2.
110. Id. § 65352.
These requirements may at first appear to create a strong collaborative link between land use and water planners, yet there are several conditions that weaken the link. First, a land use planning agency faces no consequences for failing to forward its draft general plan to the water planners. Second, although the land use agency is supposed to collaborate with the water agency in preparation of the conservation element, which constitutes “discussion and evaluation of any water supply and demand information . . . if that information has been submitted . . . to the city or county,” the collaboration requirement dissipates if the water agency does not forward information to the city or county. If land use and water planners do collaborate at this stage, however, their efforts must be reflected throughout the rest of the general plan due to the requirement that all elements of the general plan be consistent with one another.

Third, a closer look at the required coordination for updating a general plan reveals that what is minimally required could more appropriately be called a potential, one-time exchange of voluminous documents. The land use agency starts the exchange by sending its draft general plan to the water agency. Next, the water agency responds with the required information under section 65352.5 (as detailed supra). Finally, the land use agency must look at the information the water agency provides, but that “coordination” may come too late. In fact, both the land use agency and the water agency are exchanging documents in relatively final form—the city or county provides its draft general plan after it has put the bulk of its time and effort into creating the plan, and the water agency provides its UWMP, which is itself a finalized document.

The fourth condition that weakens the link between land use and water planning agencies is the possibility that the agencies could fail to coordinate at all. There are no practical consequences for either agency in any of the following scenarios:

Scenario #1: The land use planning agency sends a copy of the draft general plan to the water planning agency, but the latter simply does not

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111. One editor of this work noted that municipal use is not included in this list. Must it be accounted for? Although it seems likely that it should be, there is no definitive answer in the legislative history of the law or in case law.
112. CAL. GOV. CODE § 65352(c)(1).
113. Id. § 65302(d) (emphasis added).
respond. Although the land use planning agency has no UWMP or other information to work with, it may proceed with the finalization of the general plan.

Scenario #2: The land use planning agency fails to send notice to the water agency that it is updating its general plan, and somehow the water agency misses other required public notices. According to section 65352(c)(1), the general plan is still valid if the land use agency never forwards a draft general plan or requests information from the water agency.

Scenario #3: The land use agency provides a draft general plan to the water agency, and the water agency responds with its required information. The land use agency discusses and evaluates the information from the water agency, but decides that its own water supply projections are more reliable. The general plan will be valid as long as the land use agency has not acted arbitrarily, capriciously, or without evidentiary basis in making its decision.

Although these scenarios are obviously worst-case examples, they reveal that the statutory structure for coordination between land use and water planning agencies at the general plan level relies heavily on the good faith of the parties involved.

B. CEQA’s Link Between Water Management and Land Use Planning

Based on the National Environmental Policy Act (NEPA), the California Environmental Quality Act (CEQA) was passed in 1970 to improve dissemination of information about projects that have a significant environmental impact. In the past decade, CEQA has been invoked to link the water and land use planning processes more tightly than otherwise provided for in the Government and Water Codes. This judicial trend reflects a growing concern that land use agencies may be approving development that cannot be served by available water supply. This section begins with a brief summary of the major tenets of CEQA, and then describes four significant judicial decisions that have forged new linkages between the land use and water planning processes.

114. There is one caveat to this point. Water agencies that do not prepare and adopt an UWMP, and do not forward that plan to the Department of Water Resources (DWR), face serious consequences in the form of ineligibility for state funding. See discussion infra Section III.B. The scenario described above could still happen, however. Even if the water agency has prepared its UWMP and does forward it to the DWR but fails to send it to the city(ies) and county(ies) that are in its service area, there does not seem to be any mechanism requiring a city/county to seek an UWMP.

115. Challenges to the adoption of a general plan must be brought as petitions for writ of mandate. CAL. GOV. CODE §§ 65750, 65751. California Code of Civil Procedure § 1085 governs writs of mandate. The appropriate standard of judicial review is whether the adopting agency has acted arbitrarily, capriciously, or without evidentiary basis. See § 65750; Concerned Citizens of Calaveras County v. Bd. of Supervisors, 166 Cal. App. 3d 90, 96 (1985).


1. The California Environmental Quality Act (CEQA)

In Laurel Heights Improvement Ass’n v. Regents of University of California, 6 Cal. 4th 1112 (1993), the California Supreme Court provided an overview of the CEQA process, which has been summarized into bullet points here:

1) The Environmental Impact Report (EIR) is the “heart of CEQA.” Its purpose is to make sure that the government decision-makers, as well as the public, are informed of the environmental consequences of their decisions before they are made.

2) An EIR must be prepared “whenever substantial evidence supports a fair argument that a proposed project may have a significant effect on the environment. Significant effect on the environment means a substantial, or potentially substantial, adverse change in the environment.”

3) CEQA only applies to specific actions, which means that planning or contemplation of action does not trigger the statute.

4) Once CEQA is triggered, the lead agency (which is the agency that will approve or deny the project) must prepare an EIR that presents a detailed statement of all foreseeable environmental impacts and considers all reasonable alternatives (including a “no project” alternative).

5) The public must be allowed to comment about environmental issues, and the lead agency must evaluate and respond to those comments. In its responses, the lead agency must explain in detail its reasons for rejecting suggestions and proceeding with the project despite any environmental effects.

6) The final step of the EIR process is certification of the EIR by the lead agency. When it certifies the EIR, the lead agency must conclude “either that the project’s significant environmental effects identified in the [final] EIR have been avoided or mitigated or that the unmitigated effects are outweighed by the project’s benefits.”

7) In the land use context, only discretionary government actions are subject to CEQA (i.e. general plan adoption/amendment, specific plan adoption, zoning, and grant of tentative subdivision map), as opposed to ministerial actions which are not subject to CEQA (i.e. grant of final subdivision map, building permit, and certificate of occupancy). The exception to this general rule is general plan

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118. 6 Cal. 4th at 1123 (internal quotations removed and citations omitted).
119. Id. (internal quotations and citations omitted).
120. Id. (internal quotations and citations omitted).
121. Exempted ministerial acts are those “involving little or no personal judgment by the public official as to the wisdom or manner or carrying out the project. The public official merely applies the law to the facts as presented but uses no special discretion or judgment in reaching a decision.”
amendments and zoning changes that are approved by voter initiative. CEQA exempts projects approved by initiative.\textsuperscript{122}

8) CEQA requires only an analysis of the physical environmental effects, not the social impacts, of a given action.\textsuperscript{123}

9) Judicial review of the sufficiency of the EIR is conducted with an “abuse of discretion” standard, and the EIR will only be declared unfit if the lead agency has not proceeded according to law, or its decision is not supported by substantial evidence. A reviewing court does not rule on the lead agency’s conclusion, but rather on the sufficiency of the EIR as an informational document.\textsuperscript{124}

2. CEQA Decisions Linking Water and Land Use Planning

In the last decade, courts have increasingly interpreted CEQA to require water management planning requirements—specifically water supply requirements—during the land use planning process. As noted above, CEQA only applies to discretionary actions taken by a government agency on documents such as: (1) general plans, which serve as the primary long term visioning document of the land use planning process; (2) specific plans, which although not part of general plans, serve as a tool to implement general plans in subareas addressed by the general plan by including more concrete standards and details than a general plan; and (3) individual project approvals, such as subdivision approval.

a. CEQA and the General Plan

Four recent cases require land use agencies to establish important links between land use and water planning when taking action on their general plan.

\textbf{County of Amador v. El Dorado County Water Agency:} In \textit{County of Amador v. El Dorado County Water Agency},\textsuperscript{125} the Third District Court of Appeal overturned El Dorado County Water Agency’s (El Dorado) certification of a water project EIR and approval of the water project itself.\textsuperscript{126}

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{122} See DeVita v. County of Napa, 9 Cal. 4th 763, 794 (1995); Arnel Dev. Co. v. City of Costa Mesa, 28 Cal. 3d 511, 516 (1980).
\item \textsuperscript{123} See San Franciscans for Reasonable Growth v. City and County of San Francisco, 209 Cal. App. 3d 1502, 1521-22 n.13 (1989) (holding that any project-specific or cumulative impacts from a proposed office and retail project on the availability of child care programs were not environmental impacts and therefore not subject to CEQA).
\item \textsuperscript{124} \textit{Laurel Heights}, 6 Cal. 4th at 1132-33.
\item \textsuperscript{125} 76 Cal. App. 4th 931 (1999).
\item \textsuperscript{126} Id. at 940-41.
\end{itemize}
\end{footnotesize}
The root of the court’s concern sprang from the fact that El Dorado’s project to obtain an additional 17,000 acre-feet (af) of water per year was based “on [population] projections contained in a draft, unadopted [county] general plan.”127 The court held that if El Dorado’s project were built, then no agency would have looked at the environmental impact of providing a water supply for potential future growth.

By proceeding without the benefit of the general plan in place, and by developing projects on needs described in an unadopted plan, the CEQA process is stood on its head. . . . The issues become circular: water supply projects are adopted to meet growth plans outlined in a draft general plan, and the general plan is then adopted because an adequate water supply exists for the outlined development plans.128

The court’s holding suggests a bright line rule for counties (and presumably cities) preparing general plans or general plan amendments: some consideration of the environmental effects of water supply and development must be included, and a draft general plan cannot serve as an authoritative definition of need.

Yet County of Amador also complicates the land use and water planning processes. First, if land use agencies are required to evaluate the environmental impact of increased demand for water, it may require them to analyze environmental impacts outside of their jurisdiction.129 For example, if a land use agency is served by a waterworks that delivers water across long distances, such as the State Water Project or the Colorado Aqueduct, County of Amador suggests that the agency should evaluate the impact that its proposed development will have on the watersheds those projects draw from. This requirement may not prove to be a problem if there are relevant EIRs done by state or regional agencies studying anticipated impacts on the State Water Project or Colorado Aqueduct as a whole that the local land use agency can rely on, but otherwise it could be a large burden. Such environmental studies may be especially difficult for land use agencies to perform because, unlike EIRs for specific projects that often are paid for by project proponents, an EIR for a long-term plan may or may not have a specific project in view at the time.130

Second, if water planners must wait for the relevant land use agency to finish the general plan process before initiating their long-term water planning,

127. Id. at 940.
128. Id. at 950.
129. See Moose, supra note 55, at 39.
130. Recently passed legislation has remedied this problem to an extent yet to be determined. AB 2936, which amended Government Code section 66014, permits jurisdictions “to include the costs reasonably necessary to prepare and revise the plans and policies that a local agency is required to adopt before it can make any necessary findings and determinations.” This allows cities and counties to add a long-term planning charge into fees for zoning variances, zoning changes, use permits, building inspections and permits, and other development-related actions. See infra Section VII.B.
water agencies may not be able to complete projects in time to meet demand.\textsuperscript{131} This may be especially problematic because general plans typically look fifteen to twenty years into the future,\textsuperscript{132} yet it may take much longer for a water agency to bring a new supply project on line due to environmental and economic concerns.\textsuperscript{133}

However, the \textit{County of Amador} court did not say that the water agency must look only to the general plan for an authoritative statement of need. Under the Urban Water Management Plan Act, a water agency can use population projections from many sources to support its water demand projections, including the Demographic Research Unit of the California Department of Finance.\textsuperscript{134} Accordingly, the water agency may not be tied to the general plan at all, although such a result would be contrary to the legislative actions of the past few years that attempt to bind land use and water planning more closely.

**Planning and Conservation League v. Department of Water Resources:** In \textit{Planning and Conservation League v. Department of Water Resources},\textsuperscript{135} the Third District Court of Appeal overturned the EIR for a negotiated agreement (known as the “Monterey Agreement”) between the Department of Water Resources (DWR) and some of its water contractors. The DWR is the state agency charged with operating the State Water Project (SWP), a series of dams and canals that begins with the Oroville Dam in the north and stretches to Los Angeles in the south.\textsuperscript{136} The SWP is a major source of water in California—two out of every three Californians receives some of their water from it.\textsuperscript{137}

The Monterey Agreement was motivated in part by the water contractors’ desire to change how their contracts with the DWR handle water shortages in dry years. Article 18 of the original water contracts dealt with water

\textsuperscript{131} Moose, \textit{supra} note 55, at 40.
\textsuperscript{132} OPR GUIDELINES, \textit{supra} note 24, at 14 (2003).
\textsuperscript{133} In his remarks entitled “Show Me the Water: Quenching California’s Growing Thirst,” Randele Kanouse, Manager of Intergovernmental Affairs of the East Bay Municipal Utility District, noted that water projects proposed shortly before and after the dawn of the environmental movement in the U.S. have been very slow to achieve approval, if they are approved at all. He cited three projects that took more than three decades from proposal to completion, including the State Water Project Coastal Aqueduct (35 years), the Los Vaqueros Reservoir (38 years), and the New Melones Reservoir (40 years). He also noted four other proposed projects have been pending for decades and may never be completed, including the Shasta Reservoir Enlargement (over 20 years), the Auburn Dam (over 35 years), the Freeport Regional Aqueduct (over 30 years), and the Peripheral Canal (over 30 years). Kanouse, \textit{supra} note 26.

\textsuperscript{134} The current UWMP requirement in Water Code section 10631(a) just asks the water supplier to estimate future water demand based on “. . . data from the state, regional, or local service agency population projections within the service area of the urban water supplier. . . .”

\textsuperscript{135} 83 Cal. App. 4th 892 (2000).


\textsuperscript{137} The State Water Project makes deliveries to 2 out of every 3 Californians. State Water Project website, \textit{supra} note 136.
shortage. Subdivision (a) described procedures during drought conditions, which required agricultural users to accept larger supply reductions in order to preserve deliveries to urban contractors. Yet subdivision (b) of Article 18 dealt with a different issue—how to re-allocate water entitlements amongst the water contractors if the SWP was not fully built out. In fact, the SWP is only half completed, and it is likely that economic and environmental concerns will preclude its completion. In the event that statewide water planners acknowledge that the full build out of the SWP will not occur, subdivision (b) calls for a proportional reduction in entitlement, which would reduce all the water contractors’ entitlements by roughly half.

The court invalidated the EIR prepared for the Monterey Agreement for several reasons, but the most relevant to this discussion was the EIR’s failure to contemplate the “no project” alternative—what would happen if the agreement did not come to pass and all the contractors had their entitlements reduced by half. The contractors argued in response that removing Article 18, subdivision (b) would have little effect because contractors rarely, if ever, ask the DWR for their full entitlement, and the DWR has typically “been able to meet contractor requests except for in a few drought years.” The court refused to accept the contractors’ argument, instead pointing to the possible effects that removing subdivision (b) might have on the land use planning decisions of jurisdictions served by the SWP:

What then are the environmental consequences of removing article 18, subdivision (b), if the contractors continue to receive the same amount of water whether or not the provision is invoked? The answer is that entitlements under table A—“paper water,” so called because it exists only on paper—serve as the basis for land planning decisions. Projects that are given the clearance to proceed based upon an entitlement to X acre-feet of water might not proceed if a contractor’s entitlement is reduced to (X—Y) acre-feet.

Commenters to the draft EIR spoke directly to the issue of land use planning. One commenter pointed out,

Potential environmental effects exist because local land use jurisdictions within SWP Contractors’ service areas vary considerably in their planning responses to the availability of project water. Some . . . assume that most or all of their SWP entitlement will be available for new development. Others more reasonably assume that they will receive water in proportion to the project’s actual yield. Thus,
where land use planning determinations can be made on the basis of entitlement rather than real water, development can outpace the availability of water, leading to detrimental environmental consequences, excessive groundwater pumping, and pressure to develop additional water supplies.\textsuperscript{145}

The court’s holding can be viewed as a warning to land use agencies not to approve development based on “paper water” entitlements that may never be supplied after projects are built and demand for water is made.

Santa Clarita Organization for Planning the Environment v. County of Los Angeles: In Santa Clarita Organization for Planning the Environment (SCOPE) v. County of Los Angeles,\textsuperscript{146} the Second District Court of Appeal forcefully reaffirmed the message first made in Planning and Conservation League—no reliance on “paper water.” At issue in SCOPE was the County of Los Angeles’ approval of an EIR studying the impacts of a residential and commercial development in the Santa Clarita Valley involving 2,545 housing units, 180,000 square feet of commercial retail, and 46 acres of community facilities.\textsuperscript{147} Despite its euphemistic name, West Creek was challenged on the security of its water supply.

The court opened its opinion with a clear statement: “An environmental impact report for a housing development must contain a thorough analysis that reasonably informs the reader of the amount of water available.”\textsuperscript{148} The EIR at issue defined the water supply available to West Creek by looking to the water wholesaler for the region, the Castaic Lake Water Agency (Castaic). In addition to groundwater withdrawals, Castaic holds entitlements from the SWP for 54,000 acre-feet per year. These entitlements were used to calculate the water supply available to the agency to supply both the West Creek development and the anticipated future development in the Santa Clarita Valley as a whole.

Referring back to the holding in Planning and Conservation League, the court took issue with the EIR’s reliance on Castaic’s SWP entitlements. “As the court in Planning & Conservation League points out, the entitlements are based on a state water system that has not been completed. There is a vast difference between entitlements and the amount of water that SWP can actually deliver.”\textsuperscript{149} To provide a sufficient analysis of water supply, the court wrote that the EIR should have defined any differences between “entitlements” and “actual supply” for wet, normal, and dry years. In addition, part of this explanation should have been an estimate from the DWR, the agency charged

\textsuperscript{145} Id. (emphasis added).
\textsuperscript{146} 106 Cal. App. 4th 715 (2003).
\textsuperscript{147} Id.
\textsuperscript{148} Id. at 717.
\textsuperscript{149} Id. at 721-22.
with operating the SWP, “as to how much water it can deliver . . . [and if] no such reliable estimates are available . . . the EIR should say so.”

In vacating the county’s approval of the EIR, the court concluded that the EIR fails to undertake an adequate analysis of how much water the SWP can actually deliver . . . Without such information, the general public and its responsible officials cannot make an informed decision on whether to approve the project. The county’s approval of the West Creek EIR is not supported by substantial evidence.

This opinion is the clearest statement to date that CEQA requires a realistic discussion of a development’s water supply in its EIR. Interestingly, the court also rejected the chance to defer such a water supply analysis to a later stage in the development process by criticizing the EIR’s discussion of the water supply verification requirement put into place by SB 221. The EIR claimed that because each subdivision included in the West Creek development would have to obtain a water supply verification before its tentative subdivision map could be approved, the development itself “would not result in an unavoidable significant cumulative impact on Santa Clarita Valley water resources.” Despite this later check on development, the court insisted that CEQA requires an evaluation of a project’s water supply in the EIR. “Nor is the inadequacy cured by the requirement that Newhall demonstrate an adequate supply of water before the tract map is recorded. An EIR’s purpose is to inform. This purpose is not satisfied by simply stating information will be provided in the future.”

Save Our Peninsula Committee v. Monterey County Board of Supervisors: In Save Our Peninsula Committee v. Monterey County Board of Supervisors, the Sixth District Court of Appeal invalidated an EIR for an overdrafted groundwater basin based on the EIR’s failure to create an accurate picture of baseline groundwater usage conditions, as required by CEQA.

The property at issue was zoned for residential use and was governed by the Carmel Valley Master Plan (Master Plan), a part of the Monterey County General Plan. Monterey County received plans for the proposed development of one hundred single family homes and seventeen moderate income units in 1995. Environmental review established that the groundwater sub-basin below the property was interconnected with the groundwater basin that serves the Monterey Peninsula. This recognition immediately complicated the proposed development because the Monterey Peninsula’s water supply was

150. Id. at 722.
151. Id. at 724.
152. See infra Section II.C.
154. Id. at 723.
156. Id. at 109.
severely limited, and a decision by the State Water Resources Control Board left the project dependent on groundwater. The Master Plan had recognized this water shortage and created a policy that new development “shall be subject to County adopted water allocation and/or ordinances applicable to lands in the Carmel Valley Master Plan area.”

The case turned on how the county developed its projection of the baseline water usage on the property, which would determine the number of units that the developer would be allowed to build. First, the EIR approved by the Board of Supervisors included several different methods of projecting the baseline water usage on the project, leaving the Supervisors to pick the method they found most appropriate. The court noted that while the method of projecting water usage was within the Supervisors’ discretion, their choice of method must be supported by reasoned analysis and substantial evidence.

Second, the court took issue with the fact that one method of projecting water usage on the property included data observed after the proposed project was submitted to the county. This was significant because water usage on the property increased substantially in the years after the project was submitted, and there were allegations that the developer was increasing irrigation in order to raise the baseline. The Supervisors eventually accepted a baseline water usage figure that included water usage after the project was submitted, which the court said was “clearly faulty [because a] baseline figure must represent an environmental condition existing on the property prior to the project.”

Finally, the court held that the Supervisors violated CEQA in two ways by waiting until the end of the CEQA process to select a methodology with which to estimate the baseline water usage. First, the postponement left no time for public comment. Specifically, the court noted that CEQA requires that: (1) the public and other interested agencies have an opportunity to comment, and (2) the lead agency analyze and respond to those comments.

In sum, County of Amador, Planning and Conservation League, SCOPE, and Save Our Peninsula Committee strengthen the ties between land use and water planning. First, County of Amador states that land use planning must lead water planning; second, Planning and Conservation League and SCOPE both

157. Id. at 108.
158. Id. at 120-21.
159. Id. at 120 (“We believe CEQA requires that each alternative be supported by reasoned analysis and evidence in the record so that the decision of the agency is an informed one.”).
160. Id. at 123.
161. Id.
162. Id. at 124.
163. Id. at 125.
hold that approval of new development, at any stage in the land use process, cannot rely on "paper water," especially if the entitlement comes from the State Water Project; and third, Save Our Peninsula Committee requires a reasonably justifiable baseline of environmental conditions, including groundwater usage and condition of the groundwater aquifer, upon which decision makers can base their judgments.

b. CEQA and the Specific Plan

The courts have also addressed a city’s ability to approve a specific plan without examining the long-term water supply effects. In Stanislaus Natural Heritage Project v. County of Stanislaus,165 the Fifth District Court of Appeal invalidated Stanislaus County’s first-tier166 EIR for a specific plan detailing a 29,500 acre residential and resort development. The specific plan anticipated that the development would be built out in four phases over twenty-five years. Although the project had no onsite water supply, the EIR did not evaluate the effects of providing water for the development past the first five years.167 Instead, the county accepted the unknown future water supply as an unmitigated impact and stated that no future stages of the project would be approved without an assured source of water.168

In the court’s view, “the County’s approval of the project under these circumstances defeated a fundamental purpose of CEQA: to inform the public and responsible officials of the environmental consequences of their decisions before they are made.”169 The court held that it was not possible for the county to make an informed decision about the environmental impacts of the proposed project without having a clear understanding of the impacts that securing an off-site water supply for the whole project would have on the environment.170

166. Some proposed projects may include many phases and take years to complete. It may be duplicative and inefficient to require a full EIR that evaluates the whole project at each stage of the project. To prevent such duplication, CEQA allows tiering of environmental impact reports. Tiering means the coverage of general matters and environmental effects in an [EIR] . . . followed by narrower or site-specific [EIRs] which incorporate by reference the discussion in any prior [EIR] and which concentrate on the environmental effects which (a) are capable of being mitigated, or (b) were not analyzed as significant effects on the environment in the prior [EIR].

CAL. PUB. RES. CODE § 21068.5 (2003). EIRs should be tiered whenever the lead agency considers such tiering feasible. Id. § 21093(b). Subsequent EIRs do not have to consider environmental effects discussed in a previous EIR if those effects were mitigated by the previous EIR, or analyzed in specific enough detail to allow the current project to mitigate the effects. Id. § 21094. Tiering is also discussed in the CEQA GUIDELINES, supra note 121, §§ 15152, 15153, and 15385.
168. Id. at 195.
169. Id. (internal quotations omitted).
170. Id. at 199-200.
Stanislaus Natural Heritage holds that a county cannot approve a specific plan for a project without evaluating the effects on the environment of securing a long-term water supply for the whole project. This holding poses a timing problem that potentially conflicts with County of Amador, discussed in Section II.B.2.a, supra. Stanislaus Natural Heritage holds that the water planning agency must have reasonably certain long-term water supply answers when specific projects come asking for water. Yet County of Amador warns that the water planning agency cannot plan ahead of the land use agency. These holdings together imply that both the land use and water agencies should communicate closely with one another to prevent the missteps of one from impeding the actions of the other.

C. Recent Legislation: Land Use and Water Planning with SB 610 and SB 221

In his 2001 letter to the Legislature after signing Senate Bills 610 (Costa) and 221 (Kuehl), Governor Gray Davis wrote, “these bills will coordinate local water supply and land use decisions to help provide California’s cities, farms and rural communities with adequate water supplies. Additionally, these bills increase requirements and incentives for urban water suppliers to prepare and adopt comprehensive management plans on a timely basis.” This bland language downplays the fact that together both bills go further than any other previous steps towards integrating the land use and water planning processes.

Although sufficient time to judge the bills’ success has not yet passed, commentators expect the bills to affect the land use and water planning processes significantly. In fact, SB 221 breaks entirely new ground by requiring land use agencies to condition approval of some types of residential development on a showing that a sufficient water supply is in place to serve both the proposed project, as well as other existing and planned future uses. SB 610 follows up on Senator Costa’s previous effort in 1995 to require a water assessment before land use agencies approve large-scale projects, as well as expanding requirements under the Urban Water Management Planning Act.

171. Id. at 205-06.
172. Id. at 206.
173. Letter from Governor Gray Davis to the California Legislature, accompanying Senate Bills 221 and 610 (Jan. 1, 2001) (on file with author).
174. Zinn, supra note 53, at 130 (noting that “[h]owever they are ultimately interpreted in the courts, SB 610 and SB 221 have changed the planning landscape noticeably.”).
175. CAL. GOV. CODE § 66473.7(a)(2) (2003).
176. Senator Costa authored SB 901, encoded at California Water Code §§ 10910-15, which was a first attempt to provide for a water supply assessment process before land use agencies approved large-scale development. As one commentator noted, however, “[t]he assessment requirement [was] more often than not honored only in the breach.” Zinn, supra note 53, at 123. A study performed by the East Bay Municipal Utility District (EBMUD) in 2001 found that only 2% of the projects covered by SB 901 had complied with all of its requirements. See Zinn, supra note 53 (citing Al Herson & Ron Bass, 2001 CEQA Legislation and Guidelines Update, 2001 CAL. ENVTL. L. REP. 343 (2001)).]
Both bills address large-scale development proposals, which they describe in very similar terms. SB 221 applies to “subdivisions,” which it defines as a residential development of more than 500 units.177 For public water systems with less than 5,000 connections, however, a subdivision means any development that would increase the number of connections by 10% or more.178 SB 610 applies to “projects,” which are defined more broadly than subdivisions in SB 221, but uses a similar measure of size. A “project” is defined as a residential development of more than 500 units, a shopping center employing more than 1,000 persons or including more than 500,000 square feet of floor area, a commercial development employing more than 1,000 persons or including more than 250,000 square feet of floor area, a motel or hotel with over 500 rooms, an industrial, manufacturing, or processing plant housing more than 1,000 persons or including more than 650,000 square feet of floor area, a mixed use project with one or more segments that match any of the previously listed components, or a project that would demand as much water as a 500 dwelling unit project.179 For water suppliers that have less than 5,000 connections, “project” is amended to mean any development that would result in a 10% or greater increase in its number of connections.180

The earlier discussion in Sec. II.A, supra, analyzed the substantive and procedural requirements for the general plan separately. This segmentation, which does not exist in statute, illustrates: (1) the substantive requirements inherent in the general plan process, and (2) the degree of collaboration already required between land use and water planning agencies. This segmentation is useful for evaluating SB 221 and 610 for the same reasons.

1. Informational Requirements Added by SB 610 and SB 221

Both bills attempt to link the land use and water planning processes at multiple levels in the land use process. SB 610 requires a water assessment for any “project” (as defined supra) that is subject to CEQA. The assessment must be prepared by the relevant water agency as soon as the land use agency determines the project is subject to CEQA.181 For example, the Dougherty Valley case described in Section I.A, supra, would have triggered a water supply assessment under SB 610. Contra Costa County approved a general plan amendment and adopted a specific plan to accommodate the project, and the project was subject to CEQA.182 Under SB 610, Contra Costa County would have been required to seek a water supply assessment from EBMUD before it could have made any of the legislative approvals that led to EBMUD’s

177. CAL. GOV. CODE § 66473.7(a)(1).
178. Id.
180. Id. § 10912(b).
181. Id. § 10910(a).
182. See supra notes 28 through 32 and accompanying text.
litigation. SB 221, on the other hand, inserts a check on development at the discretionary subdivision approval stage in the planning process. Before a city or county can approve a tentative subdivision map, it must receive a water supply verification from the public water agency that will supply the subdivision. The verification must state that there is a sufficient source of water.\(^{183}\)

**Water Supply Assessment Under SB 610:** A water assessment under SB 610 is a document evaluating the ability of the designated water agency to serve the project for the next twenty years. The assessment looks at ability to meet the project’s estimated demand, as well as other existing and planned future uses (including agricultural and manufacturing uses), in normal, single-dry, and multiple-dry water years.\(^{184}\) This assessment must be supported by evidence showing the water entitlements, rights, or contracts designated for the project, and the amount of water received historically.\(^{185}\) If no water has been received historically with the aforementioned entitlements, rights, or contracts, the assessment must identify the other water agencies using the source of supply.\(^{186}\) If groundwater is the source of supply, additional detail about the status of the groundwater basin is required, including: (1) whether it has been adjudicated; (2) whether the basin is in overdraft conditions; (3) description of groundwater pumping for the past five years; (4) projected groundwater pumping in the future; and (5) a sufficiency analysis of the groundwater basin as a source of supply.\(^{187}\)

**Water Verification Under SB 221:** Similar to the SB 610 assessment, verification under SB 221 requires the designated water agency to provide “total water supplies available during normal, single-dry, and multiple-dry years within a 20-year projection that will meet the projected demand associated with the proposed subdivision, in addition to existing and planned future uses, including, but not limited to, agricultural and industrial uses.”\(^{188}\) This verification must be supported by substantial evidence, which may be provided by a water assessment, the most recent Urban Water Management Plan (UWMP),\(^{189}\) or recitation of the water entitlements, rights, and contracts detailed in the water assessment section.\(^{190}\) If the water supply noted in the

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\(^{183}\) CAL. GOV. CODE § 66473.7(b)(1).

\(^{184}\) CAL. WAT. CODE § 10910(c). The terms single dry and multiple dry water years come from the Urban Water Management Plan Act. Id. § 10631. Under section 10631(c), an urban water supplier is supposed to describe the reliability, to the extent practicable, of its water supply in the event of an average water year, a single dry water year, and a multiple dry water year. The terms are not defined with more detail.

\(^{185}\) Id. § 10910(d).

\(^{186}\) Id. § 10910(e).

\(^{187}\) Id. § 10910(f).

\(^{188}\) CAL. GOV. CODE § 66473.7(a)(2).

\(^{189}\) Analysis of the Urban Water Management Plan Act and its role in the land use planning process is provided in Section III.B.

\(^{190}\) CAL. GOV. CODE § 66473.7(c).
verification is a future source of supply that is not currently available, the verification requires proof of water contracts to serve the subdivision; documentation of a capital outlay program for financing the delivery of water; secured federal, state, and local permits to serve the subdivision; and any other necessary regulatory approvals. 191 If the project will rely on groundwater, the verification should assess the landowner’s right to withdraw the groundwater. 192 In addition, the verification must make a statement about the reasonably foreseeable impacts of the subdivision on the availability of water for agricultural and industrial users that access the same source of supply as the water agency. 193

The Urban Water Management Plan Act (discussed in Sec. III.C, infra) requires water agencies to provide much of the information required of them by SB 610 and 221. As long as water agencies are in compliance with the Act, they should be able to provide both water assessments and verifications to cities and counties that request them without much additional effort.

Both water assessments and verifications seem to require detailed water supply information that would enable a land use agency to determine whether sufficient supply exists to serve the proposed project. However, the interpretation of several critical terms could limit the effectiveness of both water assessments and verifications.

**Defining a Sufficient Water Supply.** Both assessments and verifications require an analysis of a sufficient water supply. Yet how will sufficiency be determined? In fact, sufficiency will depend on how broadly the water agency defines the phrase “planned future uses.” 194 Neither SB 601 nor 221 defines this term. One logical interpretation would require evaluation of all planned growth in the general plan. 195 SB 221 seems to require concrete proof of actual water supplies to approve development, and the general plan may include more development than the water supplier currently has capacity to serve. If localities are permitted to define what “planned future uses” means, they might shorten the timeframe of analysis, thereby limiting the long-term water planning that SB 610 and 221 seem to require.

**Groundwater.** The issue of groundwater presents another difficulty for both assessments and verifications. One commentator has noted that “groundwater rights in California are nearly as fluid as the resource itself, making identification of entitlements extraordinarily difficult. Groundwater rights are always subject to change and are not supported by solid evidence of ownership such as deeds or a system of recordation.” 196

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191. *Id.* § 66473.7(d).
192. *Id.* § 66473.7(h).
193. *Id.* § 66473.7(g).
194. For SB 601, see CAL. WAT. CODE § 10910(c) (2003), and for SB 221, see CAL. GOV. CODE § 66473.7(a)(2).
196. *Id.* at 128.
The legal structure of groundwater rights leads to several problems. First, a groundwater user with a low priority appropriative right may be able to pump water today, but in the future be required to curtail withdrawals if the groundwater basin faces overdraft. Second, according to groundwater law, a present right to appropriate groundwater does not exist until water is withdrawn. This creates a chicken and the egg problem with respect to a water supply verification. A verification must be given before a project can be approved, but the right to draw water will not exist until the project begins pumping. SB 221 clearly states that in some cases verification will be based on groundwater, which provides some support for the idea that water verification for a groundwater source should be possible. The current schema, however, does not reveal how this will happen.

2. Process Requirements Added by SB 610 and 221

What process is initiated when a water assessment is required under SB 610? First, the city or county must identify any water supplier that will serve the project, and if no water supplier can be identified, then the city or county must take on the burden of preparing a water assessment. Second, the city or county must ask the identified water system(s) whether the proposed project was considered in the most recent UWMP. If it was, then the water system can use the UWMP information in the water supply assessment it delivers to the city or county. If the most recent UWMP did not consider the project, however, then the water supplier must develop project-specific information to complete a water supply assessment. In either case, the water supply assessment must be provided to the city or county that requested it within ninety days of the request. The city or county can grant a single thirty day extension upon request by the water supplier. Once the city or county has the water assessment in hand, it is required to include it in any environmental review document prepared to comply with CEQA.

The process defined above begins as soon as the land use agency determines that the project is subject to CEQA. Despite this early beginning, however, the process calls for only a one-time exchange of information between the land use and water planning agencies—a request from the land use agency, and the water assessment from the water agency—and does not provide for any collaborative process that might allow the water and land use agencies to work together.

198. Id. at 925 (noting that “[t]he right of an appropriator depends upon an actual taking of water”).
199. See CAL. GOV. CODE § 66473.7(h).
200. CAL. WAT. CODE § 10910(b).
201. Id. § 10910(c)(2).
202. Id. § 10910(c)(3).
203. Id. § 10910(g)(1).
204. Id. § 10910(g)(2).
205. Id. § 10911(b).
agencies to work together to assure that there is a sufficient water supply for the project. Of course, SB 610 does not prevent the land use and water agencies from working together before the water assessment request is issued in order to ensure that there will be a sufficient water supply at that time.

A water supply verification under SB 221 is similar to the water supply assessment required by SB 610. The land use agency or the project applicant must request verification from the water agency before the final subdivision map can be approved.\textsuperscript{206} The water agency can use a variety of sources to prepare the verification, including a current UWMP that considers the subdivision or a water assessment prepared under SB 610.\textsuperscript{207} Unlike SB 610, however, SB 221 includes a provision that allows for a collaborative process between the subdivision applicant, the land use agency, and the water planning agency. “In making any findings or determinations under this section, a local agency, or designated advisory agency, may work in conjunction with the project applicant and the public water system to secure water supplies sufficient to satisfy the demands of the proposed subdivision.”\textsuperscript{208}

\section*{III. WATER PLANNING LAW: LAND USE CONSIDERATION IN THE WATER PLANNING PROCESS}

The 1998 California State Water Plan, prepared every five years by the Department of Water Resources, states that more than seventy percent of the state’s annual water runoff occurs in the northern third of the state, while seventy-five percent of the state’s urban and agricultural water demand exists in the southern two-thirds of the state.\textsuperscript{209} This lopsided orientation could never have come to pass without a sophisticated and complex water system. This section evaluates how water agencies charged with developing, maintaining, and operating California’s remarkable water delivery system are required to interact with their land use planning counterparts.

\subsection*{A. Agencies Responsible for Water Planning}

California’s water planning is conducted at the state, regional, and local levels. State agencies and their subdivisions regulate water rights and water quality, perform long-range water planning, and manage the large public works projects that deliver water from the north to the south. The water districts hold the actual responsibility for delivering water to the faucet. Ranging in size from districts with truly regional service areas to those with very local ones, legislative acts and judicial decisions are increasingly tying water districts to the land use planning process.

\begin{footnotesize}
\begin{enumerate}
\item\textsuperscript{206} CAL. GOV. CODE § 66473.7(b)(1) (2003).
\item\textsuperscript{207} Id. § 66473.7(c).
\item\textsuperscript{208} Id. § 66473.7(f).
\item\textsuperscript{209} STATE WATER PLAN, supra note 4, at 3-2. California also imports water from the Colorado River. See supra notes 7-10.
\end{enumerate}
\end{footnotesize}
1. State Water Agencies

Two state water agencies play a significant role in water distribution in California. First, the State Water Resources Control Board (SWRCB) controls all surface water development and transfer in California. Formed in 1967 by joining two pre-existing boards, the State Water Quality Control Board and the State Water Rights Board, the SWRCB’s mission is to balance all the water needs in the state, be they agricultural, urban, industrial, or environmental. The SWRCB is composed of five full-time salaried members, who are appointed by the Governor and confirmed by the Senate. The SWRCB has permitting jurisdiction over all surface waters and subterranean stream water, but no permitting jurisdiction over groundwater. Second, the Department of Water Resources (DWR) consolidates water planning, development, and management, subject to the oversight of the SWRCB. Its principal task is to operate the State Water Project—the system of reservoirs and aqueducts that begin in northern California and run the length of the state—and contract with state water contractors who desire delivery of water from the State Water Project. This is a critical mission, considering that the State Water Project serves 20 million Californians and 660,000 acres of irrigated farmland.

The SWRCB has divided California into nine regions, each governed by a different regional water quality control board. The mission of these regional boards is “to preserve, enhance and restore the quality of California’s water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations.” Each regional board is composed of nine members appointed by the Governor and confirmed by the Senate. The regional boards are responsible for formulating, adopting, and enforcing water quality control plans for the surface and ground water basins within their service areas. The Porter-Cologne Water Quality Control Act details the specific responsibilities of the SWRCB and the regional boards.

211. The term “subterranean stream” comes from Water Code § 1200: “subterranean streams flowing through known and definite channels.”
213. Codified as amended at CAL. WATER CODE § 120.
215. For example, the area running through the central part of California, from the northern border with Oregon to the Grapevine outside Bakersfield, is managed by the California Regional Water Quality Control Board—Central Valley Region. A map of its service area is available at http://www.srwc.ca.gov/rwqcb5/location/region_map.html (last visited Jan. 21, 2004).
For example, the Central Valley Region is responsible for the following water quality issues: (1) agricultural drainage, which may be high in selenium and other pollutants, (2) mitigation and reduction of the accumulation of salts from irrigation, (3) address nitrate levels in groundwater from agricultural fertilizers, (4) mitigate the effects of discharges of heavy metals from abandoned mines, (5) identify and control toxic pollutants to surface and groundwaters, and (6) prevent underground tanks from leaking and polluting groundwater.218

2. Local and Regional Water Districts

The concept of a special water district to raise funds and build public works to address a specific matter of public concern arose in 1861 in response to the problem of flooding.219 Since then, the concept of special districts has been applied to water supply and delivery, cemeteries, irrigation, fire protection, and the other public projects.220 In fact, water districts have proliferated in California and there are now over 1,200.221

In California, water suppliers can be broken into three broad categories. First, there are several very large, regional water agencies that serve vast areas and play a formidable role in water planning and policy in California. Foremost among them is the Metropolitan Water District of Southern California (MWD), which supplies water to approximately eighteen million Californians,222 or approximately fifty-one percent of the state’s population.223 MWD was formed by an act of the California State Legislature in 1927.224 Other significant


219. See Norris Hundley, Jr., The Great Thirst 81 (2001). According to Hundley, the Reclamation and Swampland Act, Cal. Stats., ch. 352 (1861), 355-61, first authorized the creation of such special districts.

220. Id. at 82.


223. The Demographic Research Unit estimates that the population of California on January 1, 2002 was 35,037,000. Dividing 18 million into 35 million reveals that MWD served approximately 51% of the state’s population. State of California, Department of Finance, Demographic Research Unit, E-1 City/County Population Estimates (2002), available at http://www.dof.ca.gov/HTML/DEMOGRAP/E-1table.xls.

224. Metropolitan Water District Act, 1927 Cal. Stat. 492 (repealed by Cal. Water Code § 109-550). In 1921, the Legislature passed the Municipal Utility District Act, which created the necessary authority to form the organizational structure that many water and wastewater service providers have assumed today. Cal. Pub. Util. Code § 11501 et seq.
regional water agencies include the Los Angeles Department of Water and Power (LADWP), which serves 3.8 million people and is the largest municipally owned utility in the United States;\textsuperscript{225} the East Bay Municipal Utility District (EBMUD), which serves 1.3 million households in the Bay Area;\textsuperscript{226} and the San Francisco Public Utilities Commission (SFPUC), which operates a water system that serves 2.4 million people in the City/County of San Francisco and in the East Bay.\textsuperscript{227}

Second, there are water districts whose service area only encompasses a portion of one jurisdiction, whether that jurisdiction be a county or a city. For example, the City of Stockton, located approximately fifty miles south of Sacramento, is served by twelve water districts: the City of Stockton, the California Water Service Company, San Joaquin County, the Elkhorn Golf Course Estates, the Water Maintenance District, the Rancho San Joaquin Maintenance District, CSA (County Service Area) #15, the Walnut Acres Maintenance District, CSA #17, the Lincoln Village Maintenance District, the Colonial Heights Maintenance District, and CSA #40.\textsuperscript{228}

Third, there are jurisdictions that provide their own water service. For example, the City of Davis, located fifteen miles to the west of Sacramento, provides for its own water supply and wastewater services.\textsuperscript{229}

\subsection*{B. Integrated Resource Planning (IRP)}

In the 1990s, water agencies began looking to integrated resource planning (IRP) as a way to develop a least-cost, long-term plan that meets the stringent reliability standards of water suppliers and addresses both water demand and supply.\textsuperscript{230} One scholar has further defined IRP as follows:

Integrated resource planning is a comprehensive form of water utility planning that encompasses least-cost analysis of demand-management and supply-management options, as well as an open and participatory decision-making process, the construction of alternative planning scenarios, and recognition of the multiple institutions concerned with water resources and the competing policy goals among them.\textsuperscript{231}

\begin{itemize}
\item \textsuperscript{225} See City of Los Angeles, Water Supply Fact Sheet, at http://www.ladwp.com/ladwp/cms/ladwp000508.jsp (last visited Jan. 21, 2004).
\item \textsuperscript{226} EAST BAY MUNICIPAL UTILITY DISTRICT, SHAPING OUR FUTURE: EAST BAY MUNICIPAL UTILITY DISTRICT ANNUAL REPORT 4 (2002).
\item \textsuperscript{228} SAN JOAQUIN COUNTY, GENERAL PLAN 2010, I POLICIES/IMPLEMENTATION, Table IV-4, at IV-67 (July 1992).
\item \textsuperscript{229} CITY OF DAVIS, DAVIS GENERAL PLAN, SECTION V: COMMUNITY FACILITIES AND SERVICE 199-201 (May 2001).
\item \textsuperscript{231} Id. at 42.
\end{itemize}
A key change between IRP and previous water agency planning processes is that water demand is not assumed as a given in any IRP analysis. This change in assumptions reflects the limits environmental concerns have placed on the development of new water sources, such as building reservoirs and other waterworks. MWD’s IRP process is a good example of constrained optimization of multiple objectives, or trying to balance seemingly opposed goals. The MWD noted,

The major objective for the IRP was developing a comprehensive water resources plan that ensures: (1) reliability, (2) affordability, (3) water quality, (4) diversity of supply, and (5) adaptability for the region, while recognizing the environmental, institutional and political constraints to resource development. One might think that describing a planning process as a “constrained optimization of multiple objectives” would be a politically correct way of saying that MWD did not achieve its goals through an IRP. On the contrary, MWD noted that the strengths of its IRP were: (1) achievement of one hundred percent reliability at the retail level over the twenty-five year projected life of the IRP, (2) development of the least-cost approach to sustainable reliability, (3) achievement of regional water quality objectives, (4) reduced risks to MWD through diversification of water sources of supply, and (5) flexibility to adjust future changes based on its diversified supply strategy. Although water agencies are not legally required to create IRPs, some have used IRPs as the basis for their legally mandated Urban Water Management Plans.

C. The Urban Water Management Plan Act

In 1983, the California Legislature passed the Urban Water Management Planning Act for the purpose of managing urban water supplies, encouraging efficient use of water resources, and protecting the people of the State and their water resources. SB 610 (Costa) and AB 901 (Daucher) substantially amended the requirements of the Act in 2001. According to the Act, all water districts with more than three thousand connections (or providing more than three thousand acre-feet (af) of water per year) must prepare and adopt an

232. See Kanouse, supra note 26. The State’s failure to build the other half of the State Water Project envisioned by its original designers is another poignant example. See Planning and Conservation League v. Dep’t of Water Resources, 83 Cal. App. 4th 892, 899 (2000).
234. Id. at E-15-E-16 (1996).
235. Id.
237. Id. § 10610.4.
Urban Water Management Plan (UWMP).\textsuperscript{238} UWMPs must plan for a twenty-year time horizon,\textsuperscript{239} and be updated once every five years.\textsuperscript{240} While IRP is a voluntary process that not all water agencies engage in, the UWMP is the legally required long-term planning document of the water district—the closest equivalent to a city or county’s general plan. There is one significant difference between the UWMP and a general plan—the UWMP is not subject to CEQA. Water Code section 10652 notes that “[t]he California Environmental Quality Act. . .does not apply to the preparation and adoption of [UWMPs].” Therefore, UWMPs may be less realistic documents than general plans because the environmental consequences of future projects can be left for others to consider, with less opposition from the public.

The following analysis of the UWMP process is divided into two parts. The first considers the information that must be included in UWMPs, and the second addresses the process that water districts must follow when they are preparing, reviewing, or amending their UWMPs.

1. \textbf{Informational Requirements in the UWMP}

Unlike general plans, which may include discussion of a wide range of water management-related issues (water supply, water quality, wastewater treatment and disposal, flood management, watershed management, and stormwater management), UWMPs focus primarily on water supply, with some consideration given to other issues as they affect supply, including water quality and watershed management.\textsuperscript{241} Their construction is also markedly different from general plans because UWMPs project how development will occur in five-year intervals up to the twenty-year time horizon, as opposed to providing an overall picture of how the city or county may develop within that time frame.\textsuperscript{242}

The UWMP Act recognizes the variety of specific conditions facing water districts around the state and allows UWMP construction to vary from district to district: “[t]he components of the plan may vary according to the individual community or area’s characteristics and its capabilities to efficiently use and conserve water.”\textsuperscript{243} The Act also defines what UWMPs must cover in much...
finer detail than in the comparable general plan provisions. Water Code section 10631 describes the specific issues that an UWMP must address, which are: (1) population, climate, and other demographic factors affecting supply; (2) existing and planned sources of supply and their projected yields; (3) reliability of sources of supply and vulnerability to climatic changes under average water year, single dry water year, and multiple dry water year conditions; (4) opportunities for water exchange and transfer; (5) quantity of water used in the past, measured in five year increments, for residential, commercial, industrial, institutional, and other uses; (6) methods of water demand management measures and their state of implementation; and (7) all future water supply projects under consideration by the district. In addition, section 10632 requires that the UWMP contain a contingency plan for water shortages, and section 10633 requires a discussion of recycled water as a source of supply.

Water districts must also consider water quality issues. AB 901 added section 10634, which requires that the district’s UWMP include “information . . . relating to the quality of existing sources of water . . . and the manner in which water quality affects water management strategies and supply reliability.”

Water districts may satisfy the requirements of the Act through a UWMP that considers the service area of the district, or the districts can participate in a collaborative planning effort that addresses the area, region, watershed, or groundwater basin, where “those plans will reduce preparation costs and contribute to the achievement of conservation and efficient water use.” Water districts are specifically permitted to recoup the costs of preparing an UWMP and implementing water conservation measures by raising their service rates.

The requirement to prepare and adopt an UWMP, as well as to implement it, is enforced by the threat of cutting off state funding. Section 10631.5 requires the Department of Water Resources (DWR) to consider whether the water district has begun implementing its water conservation plans when considering the district’s application for grants and loans. In addition, a district that does not prepare, adopt, and submit a UWMP to the DWR is ineligible to receive funding under the Safe, Clean, Reliable Water Supply Act or under the

244. See supra discussion in Section II.A. It is important to note that AB 901 (Daucher) and SB 610 (Costa) both proposed amendments to Water Code section 10631, substantially increasing the detail required of UWMPs.

245. The statute explicitly specifies the type of discussion it expects from water districts. It asks the water districts to identify the amount of water used among the following specific uses: single family residential, multifamily, commercial, industrial, institutional and government, landscape, sales to other agencies, saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof, and agricultural uses. CAL. WAT. CODE § 10631(e)(1)(A)-(I).

246. Id. § 10620(d)(1).

247. Id. § 10654.
Safe Drinking Water, Clean Water, Watershed Protection, and Flood Protection Act, or to receive drought assistance. Finally, section 10657 requires that the Department’s review of the district’s eligibility for funding include consideration of whether the district has provided the DWR with an updated UWMP, consistent with the requirements of section 10631.

The informational requirements of the UWMP, as amended by SB 610 and AB 901, seem relatively strict. Since they took effect on January 1, 2002, more time is required to tell how effective they will be at creating a detailed, consistent water supply reporting system in California.

2. Process Requirements in Preparation of the UWMP

Although the Act clearly contemplates water districts as the repositories of knowledge for water supply within their service area, it mandates that the districts consult others when preparing, adopting, and implementing the UWMP. The UWMP process assumes the involvement of wholesale water suppliers, the jurisdiction(s) that lie within the district’s service area, water experts, and the public. The water district must “coordinate the preparation of its plan with other appropriate agencies in the area, including water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.” Duplicating this directive, the Act also grants permission to urban water suppliers to consult with the cities and counties they serve, state agencies, and experts in water demand management. The Act also encourages urban water suppliers to solicit “the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan.” Urban water suppliers are also specifically directed to provide their wholesale water supplier, if any, with water use projections for the next twenty years, in five year time periods, and the wholesale water supplier is required to provide similar information to the urban water supplier.

Section 10621(b) requires urban water suppliers to provide notice to any city or county within their service area when they review the UWMP or consider amendments. Before adopting a plan, the water district must hold at

249. SB 610 strengthened the consequences for water districts that fail to prepare, adopt, and maintain UWMPs by adding § 10657 and amending § 10656 to bar funding under both the Safe, Clean, Reliable Water Supply Act and the Safe Drinking Water, Clean Water, Watershed Protection, and Flood Protection Act.
250. CAL. WAT. CODE § 10620(d)(2).
251. Id. § 10621(b).
252. Id. § 10641.
253. Id. § 10642.
254. Id. § 10631(i).
least one public meeting, and notify any cities or counties within its service area of that meeting. When a water district does adopt a new UWMP, it must supply a copy to any city or county that it serves, as well as to the DWR.

These process requirements contemplate no more coordination between land use and water planning agencies than the general plan requirements. Although a water district must coordinate with the other relevant agencies when preparing or adopting an UWMP, the coordination is limited by the phrase “to the extent practicable.” The requirements placed on a water district are minimal. They must notify jurisdictions within their service area that they are working on their UWMP, they must hold one public meeting, and they must forward copies of the completed UWMP to the relevant jurisdictions.

255. Id. § 10642.
256. Id. §§ 10635(b), 10644(a).
257. Id. § 10620(d)(2).
IV. THE BIG PICTURE: A DIAGRAM OF LINKAGES BETWEEN LAND USE AND WATER PLANNING

The requirements linking water and land use planning can be summarized with the visual illustration set forth on the following two pages.258 The following diagram juxtaposes the land use and water planning processes, and focuses on the points where current legislation and case law direct the agencies to interact at each stage in the process. Each planning process begins with a long-range visioning document (the general plan for cities and counties presented on the left-hand side, and the UWMP for water agencies presented on the right-hand side), and works downward to the approval of specific development and the provision of water services to such development. The arrows down the middle of the diagram reveal what exchange is directed by law. Two arrows illustrate a mutual exchange of information, while a single arrow shows a one-sided exchange.

258. The graphic depiction of land use and water planning linkages presented in this section is based on the presentation made by Randele Kanouse to the Association of Environmental Professionals Conference in 2002. See Kanouse, supra note 26.
Linkages Between Land Use Planning Agencies and…

**LAND USE AGENCY — CITY/COUNTY**

**GENERAL PLAN (GP)**
Coordinate with water agency to prepare conservation element by discussing water info. agency supplies; use UWMP as source document

Send draft general plan to water agency

Notify water agency if considering residential project of 500+ units (or equivalent development) that is subject to CEQA

Water supply discussion in EIR must be supported by substantial evidence – no “paper water.” *Santa Clarita Organization for Planning the Environment (SCOPE) v. County of Los Angeles* (2003)

**SPECIFIC PLAN**
Notify water agency if considering residential project of 500+ units (or equivalent development) that is subject to CEQA

City or county determines if water supply is sufficient

**ZONING**
Notify water agency if considering residential project of 500+ units (or equivalent development) that is subject to CEQA

City or county determines if water supply is sufficient

**TENTATIVE & FINAL SUBDIVISION MAP**
Request proof of a sufficient water supply for the project if considering a residential subdivision of 500+ units

City or county can work with the project applicant and the public water system to secure a sufficient source of water for the project

**BUILDING/CONSTRUCTION**

**WATER CONNECTIONS MADE**
...Water Planning Agencies in the Development Process

**WATER AGENCY**

**URBAN WATER MANAGEMENT PLAN (UWMP)**
Send UWMP + specific water supply info. + comments on draft general plan

**Water Supply Assessment (SB 610):** within 90 days of request, provide detailed water supply assessment to city/county

Notify city/county if reviewing UWMP
Notify city/county of public meeting regarding changes to UWMP
Coordinate w/ relevant agencies in preparing UWMP, to the extent practicable
Send UWMP to city/county & DWR when adopted

**DEVELOPMENT OF SPECIFIC WATER PROJECTS**

**Water Supply Assessment (SB 610):** within 90 days of request, provide detailed water supply assessment to city/county

**Water Supply Assessment/Verification (SB 610 or 221):** within 90 days of request, provide detailed water supply verification to city/county

City or county can work with the project applicant and the public water system to secure a sufficient source of water for the project

**“WILL SERVE” LETTER**

**WATER CONNECTIONS MADE**
V. ANALYSIS OF THE LEGAL FRAMEWORK FOR LONG-TERM LAND USE AND WATER PLANNING

What conclusions can be drawn from the preceding pages? The current scheme for long-term land use and water planning suffers from three obvious omissions. First, the Urban Water Management Plan requirement is inadequate to induce coordination and collaboration between water planners and their land use counterparts. Second, current regulations do not compel collaboration between water and land use planners early enough in their long-term planning processes. Instead, only an exchange of nearly completed documents is required, allowing planners to forego significant collaboration. Third, minimal general plan requirements for water planning miss the opportunity to induce jurisdictions to better coordinate land use and water planning.

A. UWMP Requirements Do Not Integrate With the Land Use Planning Process

The Urban Water Management Plan (UWMP) requirement for estimating future water demand is currently based on population, climate, and other demographic factors. This is problematic for at least five reasons. First, relying on population projections alone does not comport with water agency best practices for forecasting water demand. The best practices for estimating water demand in the industry today are based on looking at demographic and economic trends, translating those trends into future land uses, and projecting future demand from those land uses. For example, the Metropolitan Water District of Southern California goes beyond mere demographic data to make its projections in its 2000 UWMP.259 Even more detailed forecasting is possible if specific land uses can be tied to parcels in a Geographic Information System (GIS), and historic water use information can be applied to the parcels, according to the type of land use.260

Second, Water Code section 10631 does not standardize the source of projections data among land use and water planning agencies. Water suppliers are free to choose the population projection estimate with which they feel most comfortable (from state, regional, or local service agency). There is no requirement that the land use and water planning agencies agree on what

259. The MWD UWMP goes through a four-step analysis to project water demand. First, it uses economic and demographic projections from Southern California Association of Governments (SCAG) and San Diego Association of Governments (SANDAG) as its sources. Second, those estimates are inputted into a statistically derived water model called MWD-MAIN Water Use Forecasting System (MWD-MAIN). Third, MWD-MAIN estimates how water will be used, given demographic and economic data, among different types of land uses, including: single family residential/demand per dwelling, multi-family residential/demand per unit, and industrial/commercial/institutional/demand per employee. Finally, conservation measures are then applied to end-uses to create water demand, corrected with conservation measures.

260. The East Bay Municipal Utility District (EBMUD) is implementing this type of a system. East Bay Municipal Utility District (EBMUD), EBMUD Watershed Master Plan 91 (1996, revised 1999).
demographic and economic projections to use. It makes sense not to require a water agency to use projected data that it thinks is incorrect, but it makes no sense to allow the water agency and land use planning agencies not to talk about why each is choosing its projections source. 261

Third, water agencies are not required to use the general plan of the jurisdictions they serve as a source document for preparing their UWMP. 262 This might be explained by the fact that many general plans are significantly out of date. This omission in the Water Code is problematic given the strength of the judicial decisions and the policy arguments for basing long-term planning processes on the relevant general plan. County of Amador rejected a water project EIR based on a draft, unadopted general plan, and suggested that the general plan should be a source document for water agency planning efforts. 263 “Approving a water program before enacting a general plan places the proverbial cart before the horse.” 264 In addition, intended land use policy undisputedly affects water demand. Therefore, it makes little sense for long-term water planning not to be connected to the long-term land use plan. For example, general plans often include water-related policies, such as water conservation efforts, which should be factored into water demand figures. If water conservation policies from the general plan are not factored into water demand projections, such projections may be overstated. Finally, the new water assessments/verifications required by SB 221 and SB 610 for projects may look to UWMPs for water sufficiency if the relevant UWMP has included the project in its projections. 265 Therefore, the water agency will save itself later effort, and increase the security of development process, if it includes proposed projects in its UWMP. This will be impossible unless the water agency pays close attention to the general plan.

Fourth, the graphic depiction of the land use and water planning legal framework in Section IV, quickly reveals the hole on the land use side of the UWMP update process. There are no substantive requirements for collaboration between the land use and water planning agencies in regards to the UWMP. One possible exchange of information could be a mandatory request by the water agency for all pending projects that are expected to trigger CEQA. This exchange would ensure that the water agency could include those projects in its UWMP, which would allow both agencies to comply more easily with SB 221 and SB 610.

Finally, UWMPs, the water supply assessment in SB 610, and the water supply verification in SB 221 all require a sufficient water supply, defined as
“the total water supplies available during normal, single-dry, and multiple-dry years within a 20-year projection that will meet the projected demand associated with the proposed subdivision, in addition to existing and planned future uses, including, but not limited to, agricultural and industrial uses.” 266 The critical term in this seemingly specific definition is “planned future uses,” which is not defined in any of the statutes. This term implies some coordination with the general plan—the repository for the jurisdiction’s “planned future uses”—but the lack of specificity impairs the usefulness of the UWMP, the water assessment, and the water verification.

In his consideration of this issue, attorney Matthew Zinn notes that there are three possible ways to interpret the term: (1) use the CEQA definition of “probable future projects,” including all previously approved but unbuilt development projects (including development contemplated in Specific Plans), and perhaps projects for which applications have been submitted; 267 (2) use all development approved in the general plan; or (3) defer to individual water providers and local governments for the meaning of “planned future uses.” 268 As it stands now, the lack of connections between the UWMP process and the land use planning process undercuts all three of these possible interpretations, and decreases the likelihood of achieving the goals of SB 221, 610, and AB 901.

B. General Plan Procedural Requirements Do Not Ensure Collaboration

The foregoing discussion revealed that water planners are not required to consult with land use planners at all in the preparation of their UWMPs, despite the potential benefits that could be gained through such collaboration. In what ways are land use planners required to collaborate with their water planning counterparts?

Land use planners are required to refer to the most recent UWMP when they are preparing a general plan update, to send a draft of the general plan to the water agency before adopting it, and to consider comments returned to them by that agency. However, these requirements are too little, too late. They do not involve the relevant planning personalities in the early stages of the process. Instead, these requirements simply suggest an exchange of nearly finished or finished documents. The water agency begins by sending its UWMP to the land use agency; next, the land use agency replies with their draft general plan; and finally, the water agency sends back comments on the draft general plan. This exchange of nearly final and final documents is too easily viewed as a mere procedural requirement. Instead, there should be working groups of land use and water planners involved in the early stages of

267. See CEQA Guidelines, supra note 121, § 15130(b)(1)(B).
each other’s long-term planning processes in order to voice their mutual concerns, to gain efficiencies, and to standardize assumptions.

C. General Plan Informational Requirements Allow Minimal Long-Term Water Planning

The evaluation of the legal requirements in Section II.A.1 revealed that the informational requirements for water management planning in general plans are minimal and avoidable. Lack of specificity in some places, most notably the land use and conservation elements, robs the general plan requirement of some of the impact it would otherwise have. The requirements leave much interpretive ability to the cities and counties preparing the general plans, which may allow them to avoid, or supply insufficient discussions of, important water management planning issues.

For example, the OPR’s 2003 General Plan Guidelines, which are purely advisory, assume that the conservation element is the proper place to inventory water resources (rivers, lakes, streams, etc.), define watershed boundaries, assess water supply and water quality, and project water demand, supply, and quality. Yet the law creates no affirmative obligation to provide this information.

V. A WATER ELEMENT IN THE GENERAL PLAN

Both legislative and judicial bodies are forging linkages between the water and land use planning processes. Yet have these steps created a planning scheme that makes sense? Are there ways that water and land use planning could be integrated in a more logical or holistic way? Are agencies communicating early enough in the planning process to avoid problems?

One potential method of linking water and land use planning processes is to add an eighth required general plan element. This element would document the interaction between water issues and the jurisdiction’s land use plan. The idea has some intuitive appeal. First, the general plan is the constitution for the future development of the city or county, which guides long-term land use planning for the jurisdiction. It makes sense that long-term planning for water management should have a designated place in the general plan. Second, much of the water planning process is now scattered among three or four elements of the general plan. Consolidating them into one section may make them more easy to contemplate—both by land use planners who refer to the plan to implement policy, and by the public and other interested parties who want to understand to what the legislative body has committed itself. Third, unifying water planning into one element could make it easier for cities and counties to coordinate their planning processes with the water agencies required to do long-term water planning by the Urban Water Management Plan Act. Finally, a

269. OPR GUIDELINES, supra note 24, at 75
water element could aid cities and counties in complying with the new legislative and judicial mandates focused on assuring an adequate water supply for new development.

The idea of including a water element in the general plan is not new. At least one California county has adopted a Water Element for its general plan, and many other counties have created extensive Water Resources subsections in either the Conservation or Open Space Elements of their general plans. In addition, in the 2003 General Plan Guidelines, the Governor’s Office of Planning and Research (OPR) included an outline for a water element in its discussion of optional general plan elements.

This section begins with a brief description of the OPR’s outline for a water element. Next, it evaluates the three most complete examples of water elements already in action among a non-statistical sample of sixteen county general plans to recognize the common attributes. It concludes with a summary of seven common attributes among the three general plans that suggest possible best practices for integrating the water and land use planning processes in the general plan.

A. The Office of Planning and Research’s Optional Water Element

The OPR suggests communities create a separate water element for their general plans, in which each aspect of the hydrologic cycle is collected in a single element. Such a proposed element would consolidate discussions of water supply and demand, water quality, wastewater treatment, watershed and habitat protection, flood management, and other relevant water resource factors that previously have been scattered throughout the general plan, as detailed in Section II.A, supra. 274

Following is a brief description of the issues the OPR considers logically suitable for a water element, their connections to the land use process, and

270. As mentioned earlier, cities and counties are welcome to create additional elements for their general plans as long as they include the required seven elements. Imperial County did just that when it created a Water Element for its general plan in 1997. IMPERIAL COUNTY GENERAL PLAN, WATER ELEMENT, at 1 (1997). In addition, Inyo, Riverside, and Santa Barbara Counties have created extensive Water Resources subsections in their Conservation, Open Space, or joint Conservation/Open Space Elements, depending on how each county arranged the general plan. INYO COUNTY GENERAL PLAN, CONSERVATION/OPEN SPACE ELEMENT , ch. 8, sec. 8.5 (2001); COUNTY OF RIVERSIDE GENERAL PLAN, MULTIPURPOSE OPEN SPACE ELEMENT, ch. 5 (2003); SANTA BARBARA COUNTY COMPREHENSIVE PLAN, CONSERVATION ELEMENT, Water Resources Section, at 16 (1997).

271. The outline for the optional water element was prepared by Dr. Jeff Loux, Director of the Land Use and Natural Resources Extension, University of California, Davis. See OPR GUIDELINES, supra note 24, at 128-33.

272. In fact, of the three counties examined in detail, only Imperial County has a Water Element that is co-equal with the other elements of its general plan. The other two counties, Inyo and Riverside Counties, have extensive water resources subsections in their joint Conservation/Open Space Elements. See infra Section VI.B.

273. OPR GUIDELINES, supra note 24, at 130-31.

274. Id. at 128-33.
examples of how a community’s policies and future actions could be defined to coordinate land use and water issues.

**Water Supply and Demand:** In addition to SB 610 and 221’s requirements for water supply assessment and water supply verification, the Government Code requires that cities and counties consider UWMPs prepared by water districts that serve the jurisdiction as a source document in the preparation of the conservation element of the general plan.\(^{275}\) The water element would inventory existing water supply, analyze projected demand, assess opportunities for water conservation, project any shortfalls in supply, and consider future plans to increase water supply.\(^{276}\) Assuming that a valid UWMP is available, this section could incorporate much of the UWMP by reference.

**Water Quality:** SB 610 includes a requirement that the UWMP consider the impact of water quality on projected water supplies,\(^{277}\) but land use policies also impact water quality. Federal and state law require that “impaired” water bodies be identified and plans developed for reducing pollutants in water resources, which will require jurisdictions to modify land use plans and development policies to improve water quality.\(^{278}\)

**Wastewater Treatment:** Incorporating the wastewater treatment scheme into the water element may reveal more ways to use treated wastewater for landscape, recreation, industrial, or agricultural uses.\(^{279}\) Since the feasibility of such re-use plans can depend heavily on the proximity of compatible land uses, integrating the wastewater treatment plan with the land use element can reveal opportunities for such water re-use.\(^{280}\)

**Watershed and Habitat Conservation:** The conservation and open-space elements currently discuss watershed and habitat conservation in varying detail. There are many ways that land use policies can be set to improve watershed management techniques.

**Flood Management:** Currently the land use and safety elements require a discussion of flood management policies and actions. Consolidating that discussion into a water element corresponds with a watershed mapping effort.\(^{281}\)

**Stormwater Management:** As the earlier discussion of water quality mentioned, stormwater runoff is a major source of non-point source water pollution. Many communities face stricter requirements to manage non-point

\(^{275}\) CAL. GOV. CODE § 65302.2 (2003).
\(^{276}\) OPR GUIDELINES, supra note 24, at 130.
\(^{277}\) CAL. WAT. CODE § 10634 (2003).
\(^{278}\) See Clean Water Act, 33 U.S.C. § 1313(d) (2003) (requiring preparation of “total maximum daily load” studies of water bodies and plans to reduce the pollutant loads of those found to be impaired); CAL. WAT. CODE §§ 13000-14958.
\(^{279}\) OPR GUIDELINES, supra note 24, at 131.
\(^{280}\) Id.
\(^{281}\) Id.
source pollution. Including those policies and actions in a water element that also considers the interconnection between water supply and water quality makes sense.282

Inter-Agency Coordination, Collaboration: Clearly, integrating the land use and water planning processes is not an easy task. A water element is a good place for setting forth the policies and actions that a jurisdiction will follow in trying to coordinate and collaborate with the many neighboring, regional, state, and federal agencies that have some part in water planning.283

B. Examples of Integrated Land Use and Water Planning in County General Plans

As previous sections have shown, current legal structures do not require extensive integration of land use and water planning in general plans. Yet jurisdictions are free to do more than the law requires. How have jurisdictions in California included water management planning in their general plans? Are there any good examples of water management planning already available?284

In order to assess how closely jurisdictions have been integrating land use and water planning in their general plans, the author conducted a non-statistical survey of sixteen counties (denoted by stars in the map of California’s counties below).285 The survey attempted to balance geographic differences (coastal, inland, foothill, or mountain geography), location within the state (northern, central, southern), and level of urban development (urban, rural). How recently the general plan had been updated, whether the county was reputed to have a water element, and the availability of the general plan (either at the OPR’s

282. Id. at 131, 133.
283. Id. at 133.
284. Drawn from the self-reporting documents filed with the Office of Planning and Research by cities and counties, the California Planners’ Book of Lists 2000 includes a section that details the optional elements that cities and counties have adopted for their general plans, in addition to the required seven elements. According to that list, only nine of California’s fifty-eight counties had prepared an optional water resources element for their general plans by 2000. They were: Alpine, Humboldt, Mono, Nevada, Placer, Shasta, Sierra, Tehama, and Ventura counties. See STATE OF CALIFORNIA, GOVERNOR’S OFFICE OF PLANNING AND RESEARCH, THE CALIFORNIA PLANNERS’ BOOK OF LISTS 2000, at 43 (2000). The author’s review of these self-identified optional water resources elements found that they differed widely in what they labeled a water resources element.
285. The map is based on the Counties of California map in the PLANNERS’ BOOK OF LISTS 2000, supra note 284, at 6.
286. The author focused on a county-oriented level of analysis for several reasons. First, choosing to review a sample of the fifty-eight county general plans was more practical than attempting to do the same with the much more numerous group of incorporated cities. Second, counties typically cover a larger area and their general plans address more of the various challenges that California’s diverse territory presents to land use and water planners. Finally, the author’s bias towards regional resource planning encouraged a county-level of review. The author recognizes, however, that valuable work has also been done by cities in this area, and that cities have an important role to play in integrating land use and water planning.
offices in Sacramento, or through the internet) increased the chances of a county being included in the survey.\textsuperscript{287}
Of the sixteen counties studied, three counties in particular deserve special discussion for their extensive treatment of water management issues in the general plan. Unsurprisingly, all three of them—Imperial County, Inyo County, and Riverside County—have faced, and continue to face, especially difficult water-related challenges. Does this make them biased examples? Not necessarily. If California’s dire water forecasts prove accurate, many more areas of the state will find themselves in similarly difficult situations. If so, then the techniques these counties have implemented will be the most relevant. As the following discussion reveals, what makes the Imperial, Inyo, and Riverside County general plans interesting is how comprehensively they treat water management issues.

1. Imperial County

Imperial County is home to some of the State’s most fertile farmland. The Imperial Irrigation District (IID), one of the major water purveyors to the County, is one of California’s most senior Colorado River water rights holders.\(^{288}\) In spite of (or because of) these two factors, the County plays host to some of the most contentious water battles in the state.\(^{289}\) The County’s more urban neighbors covet its water supply, and environmentalists argue that more water should be used to preserve the critical but gradually failing Salton Sea habitat for birds, fish, and other wildlife.

Like many other Southern California counties, Imperial County is also anticipating substantial growth pressures in the form of a near-doubling of population by the year 2020.\(^{290}\) Imperial County’s response to these pressures has been to adopt a water element that stands co-equal with the other seven required elements. Imperial County is the only one of the sixteen sampled counties to have done so. In fact, the County’s general plan recognizes the critical importance of water to the County. “The history of Imperial County is tied to the availability of water, and the availability of this resource will play an

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290. See STATE OF CALIFORNIA, DEPARTMENT OF FINANCE, DEMOGRAPHIC RESEARCH UNIT, INTERIM COUNTY POPULATION PROJECTIONS (2001). Imperial County’s estimated population in July 2000 was 149,000. By July 2020, its population is projected to reach 294,200—a 97.4% increase.
important role in determining the population and economic growth of the region.”

Imperial’s water element, which was first included in the County’s general plan in 1993 and revised in 1997, has several characteristics that link water and land use planning. First, it explicitly recognizes the interconnection between water supply and land use, and suggests that the inclusion of a water element is an important step in planning with this connection in mind. On the first page of the water element, their general plan notes that “[a]n awareness of the importance of a sound Water Element is important in recognizing that water in California is becoming a scarce resource. Land use decisions based in part upon water resources have significant effects on the physical, social, and economic character of the county.”

Second, the water element addresses several significant water management issues (also suggested by the OPR’s optional water element) including: water supply and conservation, water quality, watershed management, and coordination and collaboration between the County and water agencies that serve within its boundaries.

Third, the water element includes a substantial background section that details the existing conditions and trends in water management in Imperial County. Two detailed appendices supplement this discussion: the first relates the history of Imperial County’s water supply, and the second provides a thorough assessment of the water quality of all sources of supply. These background materials indicate a level of coordination with the relevant water agencies that prepared the data (notably the IID), and provide a basis for the goals and policies presented in the water element.

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291. IMPERIAL COUNTY GENERAL PLAN, OVERVIEW, at 10 (1997).
292. Id. at 1; IMPERIAL COUNTY GENERAL PLAN, WATER ELEMENT, at 1.
293. IMPERIAL COUNTY GENERAL PLAN, WATER ELEMENT, at 1 (1997).
294. Goals 1 and 3 address water supply and conservation in the County. Goal 1: “The County will secure the provision of safe and healthful sources and supplies of domestic water adequate to assure the implementation of the County General Plan and the long-term continued availability of this essential resource.” Id. at 30. Goal 3: “The County will secure the provision of safe and healthful sources and supplies of agricultural irrigation water adequate to assure the continuation of agricultural land uses as established by the County General Plan and the long-term continued availability of this essential resource.” Id. at 31.
295. Goal 4 addresses water quality. Goal 4: “The County will adopt and implement ordinances, policies, and guidelines that assure the safety of County ground and surface waters from toxic or hazardous materials and wastes.” Id.
296. Goal 2 addresses watershed issues. Goal 2: “Long-term viability of the Salton Sea, Colorado River, and other surface waters in the County will be protected for sustaining wildlife and a broad range of ecological communities.” Id.
297. “The County of Imperial shall confer and consult with the Imperial Irrigation District and incorporated communities of the County to assure a coordinated and coherent water policy for all interested parties in the County.” Id. at 38.
298. Id. at 22.
299. Id. at A-1, B-1.
2. Inyo County

Inyo County has only recently begun to reverse the outflow of water to the City of Los Angeles from within its boundaries. That outflow is the result of an historic water grab that began almost one hundred years ago. The County’s growth has been curtailed by its early failure to manage its own water resources, and its general plan reflects a desire to prevent any additional water losses while also trying to expand the water base necessary for the County’s growth. As the Background Report to Inyo County’s general plan noted, “the control and use of water resources has had a greater effect on the county’s development in the past than any other single factor, and this issue will continue to play a large role in defining its future.”

This dusty past has caused the County to integrate the general plan’s land use and water planning mechanisms to a high degree.

Inyo County finished its most recent general plan update in December 2001 (a process that it began in 1997), and its general plan is notable for three reasons. First, when drafting the plan Inyo County made a significant effort to improve the level of participation of both the public and governmental agencies with management authority over Inyo County lands. A memorandum of understanding established the Inyo County Collaborative Planning Team in 1998, which brought local, state, and federal land use managers together every two months to talk about the plan. In addition, the County facilitated public participation by establishing land use and water advisory committees for the five distinct regions within Inyo County, organizing a community-wide full day public workshop to elicit citizens’ visions for the future of Inyo County,

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300. In 1913, the City of Los Angeles Department of Water and Power (LADWP) completed the Los Angeles Aqueduct and began exporting water from the Owens Valley in Inyo County and delivering it to the City of Los Angeles. Within eleven years, the Owens Lake was dry. INYO COUNTY GENERAL PLAN, BACKGROUND REPORT, ch. 8, at 8-26 (2001).
301. Id., ch. 1, at 1-4.
303. The Inyo County Collaborative Planning Team included the County, as well as representatives from every federal, state, and local agency that manages lands within the County or imposes regulations on the use of those lands. Many of the lands within Inyo County are managed by area plans created by the stakeholders included on the Collaborative Planning Team. The Team consisted of the following members: a member of the Board of Supervisors of Inyo County (who served as the chair of the Team), the California Department of Fish and Game (Region 6), the Lahontan Regional Water Quality Control Board, the Great Basin Air Pollution Control District, the California Department of Transportation (Region 9), the City of Los Angeles Department of Water and Power, the Inyo National Forest, the Bureau of Land Management, the Death Valley National Park, the China Lake Naval Air Weapons Center, the U.S. Department of Energy Yucca Mountain Site Characterization Office, and the City of Bishop. INYO COUNTY GENERAL PLAN, BACKGROUND REPORT, ch. 3, at 3-16 (2001).
304. The County created five advisory committees to develop land use, land release, and water system issues. The five geographically oriented committees were: Bishop Land and Water Advisory Committee, Big Pine Land and Water Advisory Committee, Independence Land and Water Advisory Committee, Lone Pine Land and Water Advisory Committee, and the Southeast County Advisory Committee (Shoshone/Tecopa area). INYO COUNTY GENERAL PLAN, GOALS AND POLICIES, ch. 1, at 1-9 (2001).
and following-up with community workshops that gave the public a chance to comment on the goals and policies of the draft general plan.305

Second, the organization and substance of the Inyo County general plan is creatively and comprehensively construed to address water management issues. The general plan distinguishes itself from most other general plans by including a separate Background Report that “provides a detailed description of the conditions that existed within the Planning Area prior to adoption of the General Plan.”306 This in turn correlates with the Goals and Policies Report that “contains the goals and policies that will guide future development within the County.”307 The Background Report has an extensive discussion on water resources that considers the regulatory framework that directs water rights and water quality issues, describes the County’s groundwater and surface water resources, details both surface water and groundwater supplies, use patterns and quality, and reports the status of the agreement between the County and the City of Los Angeles Department of Water and Power over water resources.308 In addition, their general plan includes an optional government element designed to improve inter-governmental communication and collaboration, and an extensive discussion of water resources in the joint conservation/open space element.309

The optional government element is especially relevant to the goal of integrating land use and water planning efforts. Policy Gov.-1.1 states that, 

[t]he County shall work with federal and state agencies, local districts, utilities (e.g., LADWP), and Native American tribes to ensure that they are aware of the contents of the County’s General Plan and work with them to ensure that their plans are consistent with Inyo County’s General Plan to the greatest extent possible.310

Further, Goal Gov.-2 extends the mandate for Inyo County to collaborate with other agencies beyond its own planning process, calling for Inyo County to “ensure planning decisions are done in a collaborative environment and to provide opportunities of early and consistent input by Inyo County and its citizens into the planning processes of other agencies, districts, and utilities.”311

Third, the water resources subsection of the joint conservation/open space element includes many of the elements suggested by the OPR’s optional water

305. Id. at 1-9 to 1-10.
306. Id. at 1-5.
307. Id.
308. INYO COUNTY GENERAL PLAN, INYO BACKGROUND REPORT, ch. 8, at 8-26 to 8-27 (2001).
309. INYO COUNTY GENERAL PLAN, GOALS AND POLICIES, ch. 1, at 1-4 (2001). In fact, Inyo County’s general plan includes two optional elements. One focuses on government, while the other addresses economic development. See id., chs. 3 and 5.
310. Id., ch. 3, at 3-4.
311. Id., ch. 3, at 3-5.
element, including water supply and conservation, watershed management, and inter-agency coordination/collaboration. 

Despite these attempts to integrate water and land use planning in their general plan, there are three potential problems with the Inyo County general plan’s treatment of water management issues. First, not all of the water management policies expressed in the water resources subsection are thoroughly integrated in the land use element. For example, although General Plan Policy WR-1.1 notes that “[t]he County shall review development proposals to ensure adequate water is available to accommodate projected growth,” only the commercial development land type has a policy that “[a]dequate water supplies...shall be required.” In fairness, this may be the result of Inyo County’s small size (the County’s population in July 2000 was estimated at 18,200). It may be that only commercial development creates a significant draw on the available water supply. Second, dispersion of the stormwater management and wastewater treatment to the public services and utilities subsection of the land use element, and flood control to the public safety element, could reduce the clarity of the water-related goals and polices of the County. The OPR optional water element suggests comprehensively discussing these issues together. Third, there is no policy that indicates how frequently the general plan will be updated to reflect changing conditions and policies. This may allow the general plan to lag behind the long-term planning of the relevant water agencies, although the call for continual updating included in the optional government element may reduce this possibility.

312. See Goal WR-1: “Provide an adequate and high quality water supply to all users within the County.” Id., ch. 8, at 8-20.
313. See Policy WR-3.1: “Protect, maintain, and enhance watersheds within Inyo County.” Id., ch. 8, at 8-22.
314. See Implementation Measure 1.0: “The County shall coordinate with LADWP and local water agencies to ensure that water supplies and facilities are planned to serve development planned within the County.” Id., ch. 8, at 8-23. See also Policy WR-3.3: “Support the implementation of the Long Term Groundwater Management Agreement between the County and LADWP, the MOU between LADWP, the County, the California Department of Fish and Game, the California State Lands Commission, the Sierra Club and the Owens Valley Committee, and the Inyo County Groundwater Ordinance (Ordinance 1004).” Id., ch. 8, at 8-22.
315. Id., ch. 8, at 8-20.
316. Id., ch. 4, at 4-20. Of course, SB 610 and 221’s requirements for water assessment/verification would also apply if a sufficiently large residential or industrial project were proposed.
318. See Goal PSU-4: “To ensure adequate wastewater collection, treatment, and disposal,” and Goal PSU-5: “To collect and dispose of stormwater in a matter that minimizes inconvenience to the public, minimizes potential water-related damage, and enhances the environment.” INYO COUNTY GENERAL PLAN, GOALS AND POLICIES, ch. 4, at 4-34 to 4-35 (2001).
319. See Goal FLD-1: “Provide adequate flood protection to minimize hazards and structural damage.” Id., ch. 9, at 9-12.
3. Riverside County

The challenge spurring Riverside County’s integrated water and land use planning process is the projected near-doubling of the county’s population by the year 2020.320 Beginning with a Strategic Vision adopted in October 1998, the County has engaged in an on-going, multi-year, three-part planning process known as the Riverside County Integrated Project (RCIP), which includes an update to the county general plan, a Community Environmental Transportation Corridor Acceptability Process (CETAP), and a Multiple Species Habitat Conservation Plan (MSHCP).321 When it was recently named California’s fastest growing county, Riverside County Supervisor Bob Buster cited Riverside’s planning process as its principle strength. “We’re in a very enviable position compared to the rest of the state in that we have the planning in place to turn the growth to our advantage.”322

What makes the Riverside’s general plan noteworthy? First, the general plan itself is highly creative and adds several optional elements not commonly included in general plans. For example, Chapter 2, entitled “Vision for Riverside County,” presents a written picture of the County in the year 2020 that describes the intended effects of the goals and policies of the general plan.323 Chapter 5 integrates the open space and conservation element requirements into one Multipurpose Open Space Element, and further distinguishes its discussion between resources that will be conserved or preserved by the plan.324 Chapter 10 is an Administration Element, designed to establish, maintain, and apply “the tools and procedures for interpreting the intent of the General Plan.”325 Appendix K to the general plan, the Implementation Program, includes action items correlated with general plan policies and designed to implement them.326 These additional elements contribute to the comprehensive nature, clarity, and potential for success of Riverside County’s general plan.

320. See STATE OF CALIFORNIA, DEPARTMENT OF FINANCE, DEMOGRAPHIC RESEARCH UNIT, INTERIM COUNTY POPULATION PROJECTIONS (2001). Riverside County’s estimated population in July 2000 was 1,577,700. By July 2020, its population is projected to reach 2,817,600—a 78.6% increase. In the twelve months ending July 1, 2003, Riverside County became the fastest growing county in the state.
324. The Multipurpose Open Space Element is broken into two sections: conservation and preservation. Conservation is defined as “to protect from loss of harm by using carefully or sparingly,” and preservation as “to keep in a perfect or unaltered condition; maintain unchanged.” Id., ch. 5, at OS-1.
325. Id., ch. 10, at A-1.
326. See id., app. K, i-2.
Second, the plan development process includes a diverse group of stakeholders on the plan development team, both to gather input on the content of the plan and to create a strong constituency for the plan.\textsuperscript{327} Third, water management issues receive comprehensive treatment in Riverside’s general plan, including all of the specific issues recommended by the OPR’s water element. The Multipurpose Open Space Element begins with the County’s policies on water resources (including subsections devoted to water supply and water conservation), and watershed management (including subsections on water quality, groundwater recharge, floodplain and riparian area management, and wetlands).\textsuperscript{328} The water supply subsection contains a detailed description of current and projected-2020 water demand and supply, in both normal and drought year conditions.\textsuperscript{329} Although many of the County’s water management policies are noteworthy, three policies focused on water supply are especially relevant to this Comment because they directly address the intersection of water and land use planning that have been the subject of legislation and judicial decisions:

Multipurpose Open Space Element (OS) 1.1: Balance consideration of water supply requirements between urban, agricultural, and environmental needs so that sufficient supply is available to meet each of these different demands.\textsuperscript{330}

OS 1.2: Develop a repository for the collection of County water resources information.\textsuperscript{331}

OS 1.3: Provide active leadership in the regional coordination of water resource management and sustainability efforts affecting Riverside County and continue to monitor and participate in, as appropriate, regional activities, addressing water resources, groundwater, and water quality, such as a Groundwater Management Plan, to prevent overdraft caused by population growth.\textsuperscript{332}

Fourth, the County’s water management policies are thoroughly integrated into the land use element. These policies include assessing water supply before approving development, encouraging collaboration and consistency with water

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{327} Id., ch. 1, at I-5. The General Plan Advisory Committee (GPAC) met monthly for the life of the project, and attempted to involve many different stakeholders. The GPAC membership included: two representatives appointed by each County Supervisor, and representatives from the Western Riverside Council of Governments, Building Industry Association, CA Department of Fish & Game, US Fish & Wildlife, Community Access Center, Endangered Habitats League, Sierra Club, Farm Bureau, Riverside County Office of Education, Riverside County Economic Development Agency, Riverside County Property Owners Association, and selected cities.
\item \textsuperscript{328} Id., ch. 5, at OS-3 to OS-13.
\item \textsuperscript{329} Id., ch. 5, at OS-4 to OS-6.
\item \textsuperscript{330} Id., ch. 5, at OS-8.
\item \textsuperscript{331} Id. This policy is supported by Implementation Action Item 55, which calls for the County to “[e]stablish and maintain a centralized water resource database that incorporates surface and groundwater data and provide for the public dissemination of water resource information.” Id., app. K, at 18.
\item \textsuperscript{332} Id., ch. 5, at OS-6.
\end{itemize}
\end{footnotesize}
planning agencies, and implementing the best practices set forth in the Multipurpose Open Space Element. For example, the County’s policy for all land use types that allow built structures “require[s] that adequate and available circulation facilities, water resources, and sewer facilities exist to meet the demands of the proposed land use.”

Depending on how broadly the County interprets these policies, they could initiate a water supply assessment for all projects, an even broader requirement than that contained in SB 610. Policy Land Use (LU) 1.5 directs the County to “... participate in regional efforts to address issues of mobility, transportation, traffic congestion, economic development, air and water quality, and watershed and habitat management with cities, local and regional agencies, stakeholders, Indian nations, and surrounding jurisdictions.” Policy LU 5.3 requires a review of “all projects for consistency with individual urban water management plans.”

Just one of many policies designed to implement the best management practices from the Multipurpose Open Space Element, Policy LU 4.1(d) “[r]equire[s] that new development utilize drought tolerant landscaping and incorporate adequate drought-conscious irrigation systems.”

Finally, the Administrative Element standardizes the general plan review process and sets the comprehensive review interval at five years. This is a very unusual provision, based on the author’s review of general plans. This provision addresses the problem of general plans sliding out of date.

C. Summary of Techniques to Integrate Land Use and Water Planning in General Plans

Imperial, Inyo, and Riverside counties use similar techniques to link water and land use planning. These techniques emphasize public participation in preparing the general plan, a comprehensive analysis of water management issues, a land use element that is fully integrated with the water element, regular review and update of the general plan, and provisions for collaboration and cooperation with other agencies. They also suggest that while a water element in the general plan is certainly a positive step for linking water and land use planning policies, it is not the only method to which counties have turned.

333. See Land Use Element policies LU-20.3, 22.3, 23.7, 24.7, 25.4, 26.6, 28.4, and 29.3. Id., ch. 3, at LU-52, LU-56, LU-59, LU-60, LU-61, LU-65, LU-68. Those land use types that can be served by septic facilities include the language “and/or septic capacity.” Id., ch. 3, at LU-52 and LU-68.


336. Id., ch. 10, at A-13 to A-16. The OPR’s General Plan Guidelines also suggests a five-year comprehensive review interval for the general plan. See OPR GUIDELINES, supra note 24, at 46 (“At least once every five years, each local planning agency should thoroughly review its entire general plan and revise the document as necessary.”).
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Technique 1: General plans are developed with a community-wide process that includes all stakeholders. Both the Inyo County General Plan and the Riverside County Integrated Project (RCIP) emphasized a community-wide, inclusive process to develop the general plan. By including the public, stakeholders, and interested agencies in the planning process, Inyo and Riverside attempted to gather substantive input for the content of their plans and to create a strong constituency behind the planning process.

Technique 2: Water management goals and policies address all relevant water management issues, and are presented comprehensively. Imperial and Riverside Counties both addressed, in a single water element or water resources subsection, the seven critical water management issues highlighted in the OPR’s optional water element, including: (1) water supply and conservation, (2) water quality, (3) wastewater treatment, (4) flood management, (5) watershed management, (6) stormwater management, and (7) inter-agency coordination and collaboration. While Inyo County’s General Plan also addressed all of these water issues, it did so in different elements. Imperial’s and Riverside’s summation of their policies in a single section made their General Plans seem clearer. It is likely that the difference in presentation is negligible for the professionals who use the plans on a daily basis. For the public and other interested parties who do not refer to the plan frequently, however, such comprehensive treatment may highlight important aspects of the County’s water and land use planning policies that might otherwise be missed if they did not read beyond the water resources subsection of the joint Conservation/Open Space Element.

Technique 3: Water management goals and policies are integrated in detail with the land use element. This technique seems intuitive considering the requirement that general plan elements be internally consistent. Yet, as a practical matter, plans sometimes are not consistent. There can be a range of problems from plans with obviously contradictory elements to plans that call for broad goals in one section that are not implemented by the detailed policies of another section. For example, Riverside County’s Multipurpose Open Space Element Policy OS-1.1, which calls for a balanced consideration of urban, agricultural, and environmental uses to maintain sufficient water supply, is obviously reinforced by and consistent with the many policies in the Land Use Element that require adequate water resources to meet the demands of proposed land uses before development approval. In contrast, Inyo County’s Land Use Element does not provide support for an equivalent policy in its water resources subsection.

Technique 4: The general plans set a long-term planning horizon with scheduled review/update cycles. This technique is not truly a shared one. Of

337. CAL. GOV. CODE § 65300.5.
338. See supra Section VI.B.3.
339. See supra Section VI.B.2.
the three Counties studied, only Riverside County included this policy in its
general plan. Yet the technique receives mention here because it appears to
be a serious attempt to prevent the County’s general plan from lagging behind
the Urban Water Management Plan (UWMP) process of the relevant water
planning agencies. Many of the benefits of integrated water and land use
planning begin to decline if the general plan lags behind the long-term water
planning. First, water agencies begin to lose the ability to include future
projects in their UWMPs, because those future land use decisions are not
included in the general plan. This makes the water supply assessment
requirement imposed by SB 610 more onerous for the water planning agency,
because it has less time to prepare its response. Second, considering how
quickly California is growing, some jurisdictions may face a greater workload
when they attempt to comply with SB 221 and 610’s requirements if they do
not update their general plans on a regular basis. Third, an outdated general
plan could possibly impede long-term water planning efforts if a broad
interpretation of County of Amador takes hold and mandates that water
planning agencies not get ahead of land use planning agencies.

Technique 5: Coordination/collaboration between land use and water
agencies is well-defined in the general plan. Considering that this
coordination and collaboration historically has been challenging for land use
and water planners, it is no accident that all three counties included
coordination/collaboration discussions in the water element/water resources
subsection of their general plans. For example, the Riverside County water
resources subsection directs the county to coordinate/collaborate with water
agencies by: (1) creating a repository of water resources information,(2) (2)
providing active leadership in the regional coordination of water resource
management and sustainability efforts,(3) (3) engaging in joint water
conservation educational efforts,(4) and (4) participating in groundwater aquifer
recharge programs.(5) Yet it remains unclear what this will mean in terms of
concrete action for Riverside County. This is a point where the broader view
and long-term focus of a general plan clash with the specifics that are needed to
provide a basis for performance review and goal setting.

Technique 6: The land use element expresses land use policies
through a GIS map that can be shared with water planners. State-of-the-art
GIS water demand forecasts use a model to map existing and projected land
use types. The GIS model then applies historic customer water use information

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340. As noted in supra Section VI.B.2, Inyo County’s optional Government Element includes
several goals and policies that may achieve an equivalent result to a policy that requires a regular update
of the general plan.
342. Id., at Policy OS 1.3.
343. Id., Policy OS 2.4, at OS-9.
344. Id., Policy OS 4.2, at OS-10.
to the various land use categories to project future water demand. As the land use designations of cities and counties change over time, the water agency updates its GIS model to reflect the changes in future water demand. In the same way, the effects of conservation efforts targeted at specific land uses and land use types can be included in water demand projections. This sophisticated method of projecting water demand replaces the historic practice of estimating water demand from population projections, which did not take into account large water users like commercial and industrial developments.

Advances in computer mapping technology outstrip the pace of change of most general plans. Riverside County’s plan, as the most recent effort, includes this goal more clearly than either of the other two counties. Several action items in the Implementation Program call not only for the development of a parcel level GIS map of land use types, but also for “a centralized water resource database that incorporates surface and groundwater data and provide[s] for the public dissemination of water resources information.”

**Technique 7: The general plan includes history and baseline conditions.** Imperial, Inyo, and Riverside Counties all made a substantial effort to include the history surrounding their water use, with Imperial County doing the most complete description. Imperial County included two appendices, a History of Imperial Valley Water, and a Resource Assessment, in addition to an Existing Conditions and Trends subsection in the Water Element itself. The historic and baseline conditions are important for two reasons. First, they justify the goals and policies expressed in the plan. Second, they provide the context necessary for the public and those parties interested in the general plan to understand the motivations of the County. For example, any interpretation of Inyo County’s water and land use planning policies would be incomplete without an understanding of its relationship with the City of Los Angeles and the City’s export of water from the County.

VI. CHALLENGES AND BENEFITS OF A WATER ELEMENT IN THE GENERAL PLAN PROCESS

The previous section defined how a water element for a general plan might look, described three counties that have created a co-equal water element or extensive water resources subsection in their general plans, and identified seven common techniques used by those counties. This section attempts to present objectively the benefits and challenges of a water element, providing the reasoning for each of the different perspectives that this proposal has provoked. It first argues for creating a water element in a general plan, and then presents the counter-arguments against such a proposal.

348. See IMPERIAL COUNTY GENERAL PLAN, WATER ELEMENT, at A-1, B-1, 3-22 (1997).
A. Why Create a Water Element in the General Plan?

1. Providing Better Information to the Public

One legacy of California’s struggle to channel its waters where it wills is the service district system.\(^{349}\) Owing their roots to flood control, service districts have been adopted for a wide range of municipal purposes, such as water provision, wastewater management, flood control, irrigation, trash collection, and cemetery services. For example, a citizen can be served by one organization for fresh water, another for wastewater services, and yet another for flood control. This diffusion of responsibility for water management may make it difficult for citizens to get a complete picture of what policies are being put in place.

There are two possible ways that a water element could provide better information to the public. First, by integrating water agency planning into a general plan, interested citizens, members from adjoining jurisdictions, and state officials could get a clear summary of how the jurisdiction is managing water, as well as its plans for the future. This would provide better information because few people interact with the disparate plans produced by water districts, but many people participate in the general plan process for cities and counties. Second, to the extent that a jurisdiction already includes water agency planning in its general plan but currently discusses water planning issues among several general plan elements, consolidating everything in one element will make the jurisdiction’s water-related policies more clear.

The structured process for general plan preparation will aid in the goal of providing the public with better information. While the California Legislature has given cities and counties latitude about much of the subject matter that goes into the plan and how the plan is ultimately organized,\(^{350}\) the Legislature has given specific directions about how discussion should be conducted in the document. California Government Code Section 65302 states that “the general plan shall consist of a statement of development policies and shall include a diagram or diagrams and text setting forth objectives, principles, standards, and plan proposals.” These facets—objectives, principles, standards, and plan proposals—are defined in the General Plan Guidelines produced by the Governor’s Office of Planning and Research (OPR).\(^{351}\) This format leads to

\(^{349}\) See HUNDLEY, supra note 220.

\(^{350}\) See supra discussion in Section II.A.

\(^{351}\) STATE OF CALIFORNIA, GOVERNORS OFFICE OF PLANNING AND RESEARCH, GENERAL PLAN GUIDELINES 15-16 (2003) (An objective is “a specified end, condition, or state that is an intermediate step towards attaining a goal.” A principle is “an assumption, fundamental rule, or doctrine guiding general plan policies, proposals, standards, and implementation measures.” A policy is a “specific statement that guide decision-making.” A standard is a “rule or measure establishing a level of quality or quantity that must be complied with or satisfied.” Plan proposals describe “the development intended to take place in an area. [They] are often expressed in on the general plan diagram.”).
clearer statements of development policy. If a water element were included in the general plan, it could help crystallize water management policy.

2. Helping Local Government to Comply with State and Federal Law

The most significant recent changes in land use and water law with which cities and counties must comply have come in the water supply and water quality arenas. First, courts have interpreted CEQA’s provisions to require a showing of a sufficient water supply before a project can be approved. Second, SB 610 and 221 now require detailed analysis of water supply for some large-scale projects before the projects can be approved. Although there is a limit to how specific a general plan element can be, a more thorough analysis of water supply issues in the general plan will reduce the need for subsequent analysis as specific projects come up for consideration.

Third, concerns over non-point source pollution, such as water runoff from parking lots, have increased as point source water pollution, such as emissions into a river from a factory discharge pipe, has been increasingly contained. As the federal and state governments ask cities and counties to implement plans for controlling non-point source pollution, and as development of new sources of water supply becomes a priority, water-related policies in the general plan will help jurisdictions meet water pollution requirements. Finally, both water and land use planning efforts implicate state and federal environmental laws, including the California Environmental Quality Act (CEQA), the Clean Water Act (CWA), the Endangered Species Act (ESA), and the National Environmental Policy Act (NEPA). The more thoughtfully a jurisdiction’s general plan considers the environmental values its development policies will affect, the more certain it can be that a legal challenge under one of these statutes will be unsuccessful.

3. Timely Update of Water-related Issues in the General Plan

Time frames for effective planning vary from element to element within the general plan. For example, law mandates that the housing element be updated every five years, yet effective planning for water supply should look twenty to thirty years into the future. As stated in Section II.A, supra, general plans typically look to a fifteen to twenty year planning horizon.


355. For example, Urban Water Management Plans have a twenty-year horizon. See CAL. WAT. CODE § 10631(a) (2003).
Currently, water-related issues are typically scattered among the land use, conservation, and circulation elements of the general plan. There is no assurance that each of these elements will be updated frequently enough to deal with the complexities imposed by the current statutory and judicial framework. Notably, County of Amador suggested that a water planning agency could not plan in advance of the land use agency’s general plan. If the general plan is out of date, the lack of coordination between the land use and water agencies could impair long-range water planning, leading to inefficiency and potential failures in supply planning.

By consolidating water management into a single element, however, water management issues would have a greater chance of being updated on a timely basis. Cities and counties could focus on updating one element of their general plan, as opposed to updating pieces of three or four elements, and water planning agencies could clearly point to a city’s or county’s general plan as the basis of their long-range water planning documents.

4. Reducing Future Costs: Avoiding Litigation, Preparing Environmental Documents

Recall the initial thought that California is just now seeing the foreshocks of a liquid earthquake—a future where conflict over water could be much more widespread. In order to plan for the coming conflicts, cities and counties may better protect themselves from lawsuits by clearly addressing water issues in a single water element. This element could then justify decisions made throughout the development process, including adoption of specific plans, zoning, and subdivision maps. While preparation of this element would take significant resources, it could preserve even greater resources that would otherwise be consumed in legal battles.

Judicial decisions and the water supply assessment and verification requirements detailed, supra, require extensive treatment of water supply issues in the environmental documents that must be prepared along with legislative decisions made by cities and counties. Yet, the environmental review necessary to adopt a water element could be incorporated by reference in the environmental documents required of later steps in the development approval process.

Finally, the water assessment required by SB 610 and water supply verification required by SB 221 only give water districts ninety days to provide the detailed assessment or verification. Districts can request a thirty day extension, but then a city or county may compel production of the assessment by mandamus. If the city or county asks for detailed water assessments for plans that have not been analyzed by the UWMP, the water district will need to invest a large amount of resources in analyzing the project and providing the

356. See notes 127-134 and accompanying text.
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356. See notes 127-134 and accompanying text.
necessary information. Yet, a water agency cannot include a discussion of future projects without coordinating with the land use agency. Therefore, if a water element could help to synchronize the preparation of the UWMP and the general plan, it would likely save costs to the water district down the line.

5. Increasing Predictability for Development

Depending on the type of development, the lead-time from conception to construction may take years, which introduces financial complexity. Much of the cash flow needed to fund any given development must often be contributed by the developer, who then depends on project revenues at the end of the process to recoup costs. This poses a substantial risk to the developer. If the development process is stalled by CEQA or NEPA lawsuits, or by water service providers’ recognition that insufficient supply exists to serve the development (as occurred with EBMUD in the Dougherty Valley development), the developer may face financial failure.

A water element in the general plan may help to increase the predictability of the development process. It could provide some assurance that there will be adequate supply when a specific development reaches critical approval stages. Further, it could also protect against legal challenges seeking to stop development despite approval by the relevant land use agency, as occurred in Santa Clarita Organization for Planning the Environment (SCOPE) v. County of Los Angeles and Save Our Peninsula Committee v. Monterey County Board of Supervisors, discussed in Section II.B.2, supra.

6. Synergism Between Land Use and Water Planners, Regional Planning, and Statewide Planning

Commentators have noted that water and land use planning historically have occurred as separate enterprises. Yet, the theory behind Integrated Resource Planning, discussed in Section III.B supra, notes that a higher level of collaboration between land use and water planners can result in efficiencies that have not previously been possible. A water element in the general plan that included policies for inter-agency collaboration would be one effective way to find out if such benefits could be obtained.

In addition, many experts have argued that the region is the most appropriate unit for water planning for several reasons. First, California’s

357. Morris, supra note 21.
358. The first was John Wesley Powell, an early director of the U.S. Geological Survey, but better known as the first white person to explore the Colorado River. He urged Congress to conform political boundaries in the West to watersheds, but was ignored. See ROBERT GLENNON, WATER FOLLIES: GROUNDWATER PUMPING AND THE FATE OF AMERICA’S FRESH WATERS 19 (2002). More recently, the California State Secretary for Resources, and the Chair of the State Water Resources Control Board convened a study of watershed management partnerships. Although it did not declare that California’s political boundaries should be redrawn to conform to watersheds, it did state that “watershed
geographic, demographic, and climatic differences require different management approaches. Second, the decision-making units (cities and counties) that affect demand and land use decisions are at the regional or sub-regional level. Third, localities often share common water sources, such as groundwater basins or watersheds. Accordingly, water planning performed at the regional level would seem to enable the most effective management of water supply.

If this is so, then means that further the practicality and effectiveness of regional water planning should be evaluated. A water element could contribute to this goal in several ways. First, it would promote more cooperative planning between water and land use planners, which would increase the flow of information. Second, it would give adjoining localities similar planning processes and shared documentation that could aid them in communicating about water planning. For example, a water element could serve as a source document for a regional decision-making body that coordinated land use and water impacts that crossed jurisdictional boundaries. This idea includes many complexities beyond the scope of this Comment, but the system of associations of governments, like the San Diego Association of Governments (SANDAG) in the south, or the Association of Bay Area Governments (ABAG) in the north, could be good vessels.

Finally, statewide water planners at the State Water Resources Control Board (SWRCB) and the Department of Water Resources (DWR) could refer to local governments’ water element to prepare a state-wide assessment of water challenges. Additionally, a water element would contain information relevant to the DWR, which must prepare the State Water Plan every five years. Currently the DWR receives information from the UWMPs that must be submitted by water agencies with more than three-thousand residential water connections. Yet, UWMPs are not subject to CEQA’s study and reporting requirements, and therefore may lack some of the reality of a general plan. In addition, as the court in County of Amador held, it is a general plan that determines what growth a jurisdiction will undertake. For the DWR, a water element could provide a gauge to estimate the degree of growth a jurisdiction actually will experience and the corresponding draw on water resources.

management is a very valuable and holistic approach to meeting comprehensive resource management objectives.” JOINT TASK FORCE ON WATERSHED MANAGEMENT, CALIFORNIA STATE LEGISLATURE, ADDRESSING THE NEED TO PROTECT CALIFORNIA’S WATERSHEDS: WORKING WITH LOCAL PARTNERSHIPS 8 (2002).


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B. Why Oppose a Water Element in the General Plan?

1. Another Unfunded Mandate from the State

There are few legislative actions more unpopular than unfunded suggestions or mandates from the state to counties and cities. A water element would almost certainly not be accompanied by state funding, and it is uncontested that adding a water element would be a long, expensive process for cities and counties.

This shortcoming may be remedied in some way by the recently passed AB 2936 (2002), which allows cities to recoup upfront costs spent for long-term planning. AB 2936 amended Government Code section 66014, which now permits jurisdictions “to include the costs reasonably necessary to prepare and revise the plans and policies that a local agency is required to adopt before it can make any necessary findings and determinations.” This provision allows jurisdictions to add a long-term planning charge onto fees for zoning variances, zoning changes, use permits, building inspections and permits, and other development-related actions.361

Yet, even assuming that jurisdictions can recoup their costs in the long-run, this does nothing to change the fact that all of the costs to create a water element are upfront costs. They must be borne long before development fees are collected, and the money to pay for those costs will come from programs and services currently being provided by cities and counties.

Finally, the proposed water element appears to be just another way to require cities and counties to expend money for the benefit of the state without the state paying for any of that benefit. If the state’s water managers think it would be useful to use the water elements from each county as a source document for the State Water Plan, then the state should contribute State Water Plan funds to equalize the local cost-state benefit equation.

2. Difficulties Measuring the Cost-Benefit Equation for a Water Element

Why assume that a water element will save costs in the long-run? There are at least three reasons to be suspicious of a justification based on the idea of future savings. First, how do the proponents of such an element expect to measure the benefits of a water element? How can we accurately calculate benefits when they are expressed as intangibles, like cost savings for litigation that never occurs, environmental documents that are more easily prepared, or additional security in the development process?

Second, why assume that there will be fewer lawsuits under CEQA if a water element is in place? Although it may make it more likely that the city or county will be upheld on a CEQA challenge, those upset with a jurisdiction’s

decision to develop or not develop may still sue to bring their case in the court of public opinion. It seems more likely that a jurisdiction’s costs will actually increase if it prepares a water element because of an unchanged number of lawsuits and the added cost of creating a water element.

Third, the benefits of a water element are overstated because for many jurisdictions developing a water element will only involve a reorganization of many issues already presented in detail in a general plan, as opposed to a truly new contribution to the planning process. Cities and counties may respond to the recent changes in the law, notably SB 221 and 610’s water supply assessment and verification requirements, as well as recent CEQA case law, by providing more extensive discussions of water supply in their general plans in sections that already discuss water supply. In this case, reorganizing the presentation into a single water element may have little or no affirmative benefits.

3. Experience with the Housing Element in the General Plan Suggests that Implementation of a Water Element Could Be Problematic

A root motivation behind the idea of a water element is to encourage cities and counties to consider the impact of their growth on the region. Water is a shared resource and neighbors’ use of water resources impact one another. Attempting to focus local attention on regional issues, especially when local and regional interests conflict, is a very challenging problem in regulation. Currently, the only required element in the general plan that attempts to do this is the housing element. Thus, the issues associated with the housing element in the general plan are illustrative of the problems that could potentially plague a good faith attempt to implement a water element in the general plan.

The housing element differs from the other required elements of the general plans in that it is the only element that must be updated regularly (it is on a five-year update cycle), and is the only element subject to state oversight—the state Department of Housing and Community Development (HCD) evaluates the ability of each jurisdiction’s housing element to accommodate its share of the statewide demand for housing. The purpose of the housing element is to encourage cities and counties “to make adequate provision for the housing needs of all economic segments of the community.” This goal includes the development of affordable housing for both low- and moderate-income households according to the jurisdiction’s “fair

362. Id. § 65588(b). During the 1990s, the Legislature allowed cities and counties to postpone their updates of the housing element due to budget shortfalls. See PAUL G. LEWIS, PUBLIC POLICY INSTITUTE OF CALIFORNIA, CALIFORNIA’S HOUSING ELEMENT: THE ISSUE OF NONCOMPLIANCE 2 (2003).
363. CAL. GOV. CODE §§ 65580-65589.8.
364. Id. § 65580(d).
share” of the region’s housing, as determined by HCD with information from the relevant Council of Governments (COG).365

What problems has California experienced with the housing element requirement? First, ensuring that cities and counties comply with the requirement has been challenging. A September 2002 HCD report, cited by a recent Public Policy Institute of California (PPIC) study, noted that one-third of cities and one-fifth of counties in California were out of compliance with the housing element requirement at that time.366 In addition, jurisdictions have been able to comply with the letter of the housing element requirement, without complying with the spirit of the law.

Second, the PPIC study did not find a statistical correlation between compliance with the housing element requirement and housing growth.367 It examined housing growth throughout the 1990s in communities that complied with the housing element requirement.368 The study found that “a city’s demographic characteristics, its position in the urban hierarchy, and its physical capacity to accommodate new buildings are better predictors of housing growth” than compliance with the housing element requirement.369 Ironically, however, the study did find a correlation between lack of compliance with the housing element and higher percentage construction of single-family homes, as opposed to multi-family housing.370

The PPIC study concluded that the housing element requirement was hampered by conflicting goals, as well as by its sheer length and complexity.371 The housing element requirement seeks to both maximize housing production while assuring that each city or county bear its “fair share” of the regional housing need. Yet these goals can conflict, especially in high-cost communities where building affordable housing is more difficult and expensive. In such places, it is impossible to both maximize housing development and balance housing share.372 Not only are the housing element’s internal goals in conflict, but also the element’s mandate to build housing contradicts planning laws that restrict development. For example, “[t]he state’s new law requiring that local governments identify a 20-year supply of water for new housing developments

365. A COG is a “single or multicounty council created by a joint powers agreement . . . .” Id. § 65582(b). Each COG is responsible for doing studies that provide population and economic forecasts that HCD can use to determine each region’s fair share of the region’s housing. Id. § 65584(a). The COG is then responsible for determining each jurisdiction’s share of the regional housing need. Id.
366. CALIFORNIA’S HOUSING ELEMENT, supra note 362, at 3-4.
367. Id. at x.
368. Id.
369. Id.
370. Id.
371. Id. at 88.
372. For example, if one were trying to maximize production of housing above all else, then building more housing in low-cost communities, instead of trying to build equally in high-cost communities to assure they built their “fair share,” would satisfy that goal. However, if one were trying to assure that each city bore its “fair share” of affordable housing, then the variation in building expense among cities would not change the decision to site housing in one city or another.
before approving them also sends a different signal from housing element policy.”

Further, the PPIC report notes that the lengthy and highly detailed housing element requirement impedes easy understanding, either in its entirety or in its details.

California’s thirty-three years of experience with the housing element requirement presents cautionary lessons for those considering the adoption of a water element. First, conflicting goals and policies would likely be a significant challenge in adopting a water element. As a preliminary matter, every element within the general plan must be consistent, and it is possible that a jurisdiction’s water element and housing elements could reflect conflicting goals. For example, the water element could set policies that restrict where housing can be built, while the housing element sets policies that decrease development review in order to promote housing development. Second, water is just as contentious an issue as housing, and the housing element experience has shown that regulation of contentious issues tends to create regulations that are highly detailed, lengthy, and difficult to apply. In fact, this Comment has already suggested that current regulations are not detailed enough to prevent wide variation in interpretation of informational requirements in the general plan. The housing element experience tells us that there may be some point where such complexity overwhelms the benefits of uniformity. In conclusion, water management planning may prove even more difficult to regulate than affordable housing.

4. Water Element May Become an Exclusionary Tool

Another significant danger is that jurisdictions will use a water element to impose an unfair barrier to growth that pits those who would like to become part of a community against those who already live there. There are significant public policy issues here, including: (1) should existing residents be allowed to profit by restricting growth and realizing gains in their property values?; and (2) will a jurisdiction be allowed to cite water issues as a reason not to provide affordable housing, thereby excluding a class of people from becoming residents? Without careful design, the implementation of a water element may produce these troubling results.

5. Water Element May Not Be Suitable for All Jurisdictions

It is important to restate that not all cities and counties are in similar positions when it comes to evaluating the efficacy of a water element for the general plan. In Section III.A.2, supra, this Comment identifies three general categories into which the relationship between the city or county and the water

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373. CALIFORNIA’S HOUSING ELEMENT, supra note 362, at 89.
374. Id. at 89-90.
375. See id.
district(s) that serve them can be classified. First, in some places a single water district serves multiple cities and possibly multiple counties. For example, Metropolitan Water District of Southern California serves as the water wholesaler for over half of the state’s residents. Second, two or more water districts may serve some cities and counties. Third, still other cities or counties may provide water services themselves. The efficacy of creating a water element, and the ease with which one can be prepared, will differ among these categories.

CONCLUSION: RECOMMENDING A COURSE OF ACTION FOR THE OPR AND THE DWR

This Comment began with the thought that California is just beginning to see the foreshocks of a liquid earthquake—a future where intense conflict over water supplies will pit jurisdictions against one another and test community values. If California truly will see shortfalls of 2.4 million acre-feet (maf) in normal years and 6.2 maf in dry years by the year 2020, and if the changes associated with global warming anticipated by scientists materialize, then now is the time to integrate land use and water planning to the highest degree possible. Both the economic prosperity and environmental integrity of the state depend on it.

One important step towards greater integration of long-term land use and water planning is understanding the current regulatory scheme. This Comment provides a detailed analysis of the water management requirements included in the long-term land use and water planning processes, as well as a visual depiction of the connections between them. In addition, it points out several gaps in the regulatory scheme, notably problems with the Urban Water Management Plan requirement, and opportunities for increasing both the informational and procedural requirements for general plans. The author recommends that the OPR and the DWR encourage policymakers to consider filling these gaps in the long-term planning processes.

This Comment also analyzes the idea of a water element for general plans. The concept is attractive for several reasons. Such an element would be consolidated and measurable, facilitating the comparison of general plans among jurisdictions. The water element also lends itself to oversight by a state agency, such as the DWR, which could benefit from a uniform way to gain information about water planning throughout the state. Finally, a water element would present a more intuitive picture to the public, to whom local governments owe a duty to provide information about the water challenges facing their homes and the steps being taken to assure that there will be a quality water supply for the long-term.

376. Metropolitan Water District of Southern California, 2002 Annual Report 2 (2002). In 2002, MWD was the wholesale water distributor for eighteen million Californians, approximately fifty-one percent of the state’s population.
But cities and counties may not need to create a water element in order to benefit from many of the other gains mentioned in Section VII.A, *supra*. Of the three counties analyzed in detail, only Imperial County has a fully coordinated water element. The other two counties—Inyo and Riverside—integrated land use and water planning by comprehensively discussing water management issues in one place in their general plans. The discussion retains its value whether it takes place in a co-equal water element or in a water resources subsection of a Conservation/Open Space Element (as it did in the Riverside County plan).

The County of Riverside embarked on a lengthy, substantial effort to create a vision for 2020. Riverside County’s residents see the writing on the wall—a projected 78.6% increase in population by 2020 and the prospect of urbanization, similar to that experienced by its neighbor, Los Angeles—and they have made a plan to channel and shape that growth.377 It will be fascinating to look back at their plan in 2020 to see how closely it conforms with reality. But could the state have regulated in a way that prompted Riverside to create its current plan? California’s experience with the housing element requirement for general plans tells a cautionary tale. A substantial portion of the state’s cities and counties do not comply with the requirement. A recent study by the Public Policy Institute of California (PPIC) found that the highly detailed, lengthy housing element law is difficult to understand. It also found that the law subjected cities and counties to competing policy objectives. Most frightening, the study did not find a correlation between production of housing and compliance with the housing element requirement. While this does not mean that the housing element is a useless planning requirement, it does suggest that it is not an effective tool for compelling jurisdictions to do what they otherwise would rather not do.

The idea of a water element makes sense. If jurisdictions adopt water elements, they will benefit from the effort invested in creating them. Yet, a good idea when done under the initiative of the individual jurisdiction might turn into a bad idea if required of all cities and counties. Long-term planning for land use and water is just as contentious and complex as affordable housing issues, if not more so. The two regulatory frameworks parallel one another in many ways, and California’s thirty-three years of experience with enforcing the housing element requirement should not be discounted.

The DWR should support the integration of comprehensive treatment of water management issues in one place in the general plan, as did the OPR in the *2003 General Plan Guidelines*. Whether that happens in a water element, or in a conservation/open-space element that is highly correlated with the land use element, seems less significant. The DWR should include a favorable review of

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the water element concept in its 2003 update of the State Water Plan.\textsuperscript{378} Both of these documents could serve to put the land use and water planning communities on notice that new expectations are being placed on them.

Next, both the OPR and the DWR should continue to build the collaborative capacity of land use and water planners by implementing the proposals listed above, and instituting other creative ways to achieve that goal.\textsuperscript{379} Money and technical support to help jurisdictions develop the collaborative processes and data necessary to comprehensively examine water issues in the general plan are critical. Sponsoring joint workshops that invite best practice presentations from water and land use agencies that have begun to collaborate effectively and have recognized benefits from such collaboration is also a useful step.

Another variable in this whole discussion is the UWMP update process. Statute requires that UWMPs be updated in years ending in five and zero. A reasonable approach may be to provide incentives that encourage land use agencies to update the water management-related sections of their general plans alongside their water planning counterparts during the 2005 iteration of the UWMP update process.

The next step could be to encourage water element updates with technical support and outreach on the same interval as the UWMP process—in years ending in zero and five. Considering that such a water element would also require a CEQA review, preparation of a water element for most jurisdictions would need to begin by some time in 2006 or 2007 in order to coordinate the joint preparation of the general plan element and the UWMP. Placing both the water element and the UWMP processes on the same update schedule would encourage collaboration between land use and water planning agencies because both entities would need information that the other possessed. That gives the OPR and the DWR just less than five years to build capacity and support among the land use and water planning constituencies, and for recent legislation to develop a reviewable track record in practice and in the courts.

This Comment leaves substantial questions for further research. A logical first step would be consideration of how other states have addressed the challenge of integrating the land use and water planning processes. A second would involve a detailed analysis of the costs and benefits of implementing a water element, as well as methodology to measure cost savings. This Comment

\textsuperscript{378} The DWR projects that the 2003 update of the State Water Plan will be available on December 31, 2004. See http://www.waterplan.water.ca.gov/b160/committee/calendar#October2004.

\textsuperscript{379} From his interactions with the Office of Planning and Research and Department of Water Resources staff, the author was impressed by the expertise, helpfulness, and commitment shown to him by the professionals in both agencies. It is one thing to perform legal analysis in an academic setting, but quite another to create policy, interpret regulations, and provide assistance to jurisdictions throughout the state, who may or may not be in conflict with one another. This Comment is not intended to take issue with the performance of either agency, but rather, to underscore that their service to the state is becoming even more vital (if such is possible) than it already has been.
has posited that the savings of a water element would outweigh its upfront costs by reducing the cost of project-level environmental reviews, avoiding litigation, increasing the certainty of the development process, helping water planning agencies improve their long-term water planning capabilities, and reducing the costs of their water supply assessments and verifications. Developing a methodology to check these assumptions with the actual experiences of the jurisdictions that have begun to implement water elements already, such as Imperial, Inyo, and Riverside Counties, would be one way to proceed with this analysis. Third, the limited review of county general plans conducted in this Comment should be expanded and continued to develop a more accurate understanding of what steps jurisdictions are taking to integrate water and land use planning in their general plans.

As the rumbles of growing water conflict in California highlight the intersection of water and land use planning in the collective consciousness, reasonable people have begun to ask how well we are planning for future growth and whether the water will be there to serve growth when it arrives. The past decade has seen substantial improvement in the linkages between water and land use planning, including the recent passage of SB 221, SB 610, and AB 901, as well as a series of judicial decisions under CEQA. By encouraging cities and counties to incorporate water issues into their general plans, and by advocating for stronger ties between UWMPs and general plans, the OPR and the DWR will take positive steps towards helping California plan for a challenging water future.
Customer and Stake Holders Survey for Water Plan Update 2003
We need your input. The Department of Water Resources (DWR) is now preparing the California Water Plan - Update 2003 for release at the end of 2003. We are committed to a collaborative, stakeholder-driven approach for preparing Update 2003, with broad public participation. That is where you fit in. We want to know how we can make the Water Plan more useful to you. That is why we developed an Internet survey for customers and stakeholders of Update 2003.

State law requires DWR to update the California Water Plan, also known as Bulletin 160, every five years. The California Water Plan is many things to many people. It provides a framework for water managers, legislators, and the public to consider options and make decisions regarding California's water future. The Plan presents basic information on California's water resources, including water supply evaluations and assessments of agricultural, urban, and environmental water uses. The Plan quantifies the reliability of water supplies to its various uses. It also identifies and evaluates existing and proposed statewide demand management and supply augmentation programs and projects to address the State's future water needs.

The survey takes only about 10 minutes to complete. To take the survey, just click on: www.tec-web.com/cawaterplansurvey/Login.asp

When it asks for your username enter your first and last name, and for the password enter "cawater01".

Thank you in advance for helping make Update 2003 a more useful resource.

Sincerely,

Jonas Minton, Deputy Director
California Department of Water Resources
Customer Survey

See the previous page to read the letter from DWR’s Deputy Director, Jonas Minton, inviting you to take the survey.

What is the purpose of the survey?

The purpose is three-fold:
- Marketing - to increase awareness and acceptance (e.g., expanding our user base, increasing credibility through stakeholder buy-in)
- User Needs Assessment - to answer, "How can the Water Plan best assist existing and potential Water Plan users with their missions?"
- Evaluation – to answer, "What can we do better and how?"
- What is the main question we are trying to answer?

How can we make the Plan more widely read, understood and useful?

Who is the target audience?

The target audience is very diverse as we are trying to reach existing as well as potential new users. This expands the audience of government, private and non-profit entities to include land use planners, natural resources planners, environmental and social advocacy groups, business sectors (e.g., agricultural, real estate, financing), professional associations, academic institutions, water planners, wholesalers and retailers, and similar individuals and groups.

How will we use the information?

Two key deliverables resulting from this survey will be: (1) a summary of user suggestions; and (2) correlations intended to tell us which elements of the plan are most and least used/useful and to whom. We will capture all of these suggestions and correlations and share them with the public Advisory Committee for Update 2003. Based on their input and DWR resources, suggestions and insights will either be incorporated into Update 2003 or will be available for use by the Update 2008 team.
Customer Survey Graphical Results

Respondent Category

Geographical Region of Interest

Category

Geographical Region
Planning Horizon

<table>
<thead>
<tr>
<th>Year</th>
<th>% of Total Responses</th>
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<tr>
<td>2010</td>
<td>60</td>
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<tr>
<td>2030</td>
<td>10</td>
</tr>
<tr>
<td>2050</td>
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</tr>
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Issues of Concern

- Water Service Reliability
- Investment in New Facilities
- Stationing of Existing Reserves
- Energy Reliability
- Economic Development
- Aging Infrastructure
- Food Reliability
- Reduction in Snowpack
- Greater Food Prices
- Less ability to Recharge and Store
- Rising Water Levels
- Water Quality
- Air Quality
- Species Protection
- Recreation
- Farm Land Preservation
- Traffic Conservation
- Green Space Planning
- Emergency Response Planning

Responses: Very Concerned, Somewhat Concerned, Least Concerned
Financing Strategies and Guidelines for Funding Water Resource Projects
By David Kracman, The Flatwater Group
Financing Strategies and Guidelines for Funding Water Resource Projects

by David Kracman, The Flatwater Group

As California considers implementing new water resource projects, one important part of the debate that has attracted a large amount of attention involves how to deal with the associated costs. Money and water are both finite resources, and even when everyone agrees that a project should move forward, planners and decision-makers are still faced with the problem of how to pay for it. Given the many challenges associated with finding sufficient, reliable sources for water resource financing in the future, it may be helpful to consider a few fundamental strategies and guidelines. Each project is unique, and there is no one-size-fits-all approach to financing that will work in every situation. Instead, the purpose of this discussion is to highlight a few activities that may be either effective or ineffective in helping to achieve sufficient project funding.

In the most basic terms, obtaining adequate funding for water resource projects involves answering two primary questions:

1. Who will pay?
2. How will payments be made?

Although seemingly simple, these two questions continue to frustrate efforts to fund critically important projects throughout California. The most clever analytical techniques and sophisticated economic models cannot change the hard fact that, for a proposed project to become a reality, someone must pay for it and determine how to make those payments over time.

Before addressing these questions, it’s important to consider a few other issues in the funding process. To successfully finance a water resources project, decision-makers must know how much a project will cost in the first place – which can be particularly challenging for larger, multi-purpose projects. In turn, a good cost estimate requires a well defined project, while project features and descriptions can often still be in flux late into the planning stages. This is one of several “chicken and egg” problems inherent with project financing; while some believe an ideal funding process should occur linearly over time, in a step-by-step fashion, actual conditions often dictate an iterative approach instead. As projects become better defined, more informed cost estimates can be developed, and strategies for cost recovery can be tailored to meet those particular financial needs.

The development of cost estimates for water resources projects should, and often does, bring up another question among planners,

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1 For a more comprehensive and technical discussion of many of these topics, see “DWR Economic Guidelines” (Draft), DWR Economics Analysis, December 2004.
legislators, and concerned members of the public: is the project cost-effective? In other words, do the results generated through project implementation justify spending the money to complete it? To answer this question, planners have traditionally turned to certain established economic procedures to compare the costs of a project with the resulting benefits. Known as cost-benefit analysis, this technique is used for a variety of efforts, including water resources projects, and can play a large role in the funding process. Before a decision is made to proceed with project implementation, planners may insist that the required investments will be justified by the resulting positive outcomes. Cost-benefit analysis can also be used to compare potential alternative projects and help choose the one that yields the biggest “bang for the buck”.

One of the most difficult parts of a cost-benefit analysis, and potentially with other financing steps, is the estimation of project benefits. Although describing the benefits of a project may appear to be simple, in practice the process can be nearly impossible. Part of the difficulty is associated with benefits that have a non-monetary component, such as habitat protection or aesthetic improvement. Although these features can be of considerable value to society, assigning dollar figures to them always involves a great deal of uncertainty, even with the use of the most advanced economic techniques.

Despite the challenges associated with determining benefits, there may be several advantages in describing benefits as thoroughly as possible. Understanding the benefits of a project is critical not just for purposes of cost-benefit analysis, but also for determining how to pay for project costs, and for accountability reasons. The projects coordinated under the CALFED Bay-Delta Program serve as a timely reminder of the importance of describing benefits. CALFED projects have recently come under increasing scrutiny for being unable to show meaningful benefits – whether in terms of money saved, fish survivability, or other metric – given the billions of dollars already spent under CALFED. Defenders of the CALFED Program argue that real, significant benefits have resulted from CALFED, and considerable efforts have been, and continue to be, made to inventory and track benefits associated with CALFED projects. Unfortunately, whether the benefits have not been effectively identified and conveyed to government officials and the general public, or because the benefits are in fact not commensurate with project costs, CALFED is under attack for not meeting expectations. Regardless of which argument is true, estimating benefits lies at the heart of CALFED’s accountability dispute.

Under the current fiscal environment, it is becoming more important to be able to show that benefits justify expenditures. As a result, there is greater incentive for project planners to invest the time and effort to adequately describe the benefits of program actions and estimate project costs. If project proponents wish to seek funding from federal or State sources, they may be more effective by presenting a defendable and comprehensive list of benefits that would result from those appropriations. Local sources also often demand to know where their taxes, fees, and other revenues are going, and what they are getting in return. In each case, using a transparent process of identifying and describing project benefits, and determining the relative balance of costs and benefits, can be beneficial in seeking adequate funding.

Who Will Pay?
Assuming that, through some form of cost-benefit analysis, it has been determined that implementing a certain water resource project is in the best interest of the State, the next step for
planners is to decide how to pay for the resulting costs. Economists have devised a technique for assigning cost responsibilities known as **cost allocation**, through which project costs are distributed across project **purposes**. The word “purpose” as used here has basically the same meaning as “benefit”, and may include categories such as recreation, flood control, and irrigation supply. Cost allocation is an incremental step in the funding process through which costs are assigned not to individuals or groups of individuals, but to the benefits of the project itself. Several methods exist for allocating costs, and special techniques are required for multipurpose projects for which certain costs are used to pay for multiple benefits, but the general goal is to divide costs equitably across project purposes (benefits).

While cost allocation moves the funding process one step closer to determining who should pay, it also can stir up a hornets nest concerning the issue of what to include in the list of benefits. For example, some may argue that certain project actions should be considered as new benefits, with repayment responsibilities falling on the parties receiving the benefits. For others, the same project actions might be considered mitigation for past harms created by another entity, and that entity should be responsible for project costs. Inherent in this disagreement is the idea of a **baseline** — another term whose definition may depend on the individual using it — used to establish a time or set of conditions from which to start counting contributions and project actions. This issue of mitigation versus enhancement has been an important part of funding discussions for fish screens, with environmental interests arguing that water users should pay for the screens as mitigation for past harms to the fish resulting from the diversions, and water users (often irrigation districts) arguing that others should pay for the improvements made to existing fish conditions. The core of the dispute, once again, concerns how to define benefits.

After cost allocation, the next step is the actual process of determining who will pay for the project costs through a technique called **cost apportionment**, also referred to as **cost-sharing**. Federal guidelines define this process as the division of costs between federal and non-federal entities. Water resources planners may need to further apportion costs between smaller groups of **beneficiaries**, depending on the type of project involved. Beneficiaries are the actual groups of people receiving benefits from the project. The general goal of cost apportionment is to connect the project benefits with the beneficiaries, and then equitably allocate the costs linked to the benefits accordingly across the beneficiaries. Beneficiaries receiving benefits from certain project components would, as a result, bear some responsibility for paying for the costs required to create those benefits. CALFED has established this concept as the “**beneficiary pays**” principle, and in its recent finance efforts developed a list of beneficiaries which include categories such as recreation users, and CVP and SWP water users².

Identifying the beneficiaries can be a difficult challenge in the water financing process, in part because of the iterative nature of the process itself, as mentioned earlier. Some projects evolve as the needs become more clear, resulting in different purposes and benefits, and correspondingly different beneficiaries. New storage reservoirs, for example, have been studied for several locations throughout the State under the Surface Storage Investigations Program, but since it is still unresolved exactly how the reservoirs would be operated and for what purposes, both benefits and beneficiaries are still unclear. In turn, potential beneficiaries have been reticent

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² For more information, see “CALFED Bay-Delta Program Finance Plan”, California Bay-Delta Authority, January 2005.
to define the benefits they might receive since project operations have not been finalized. These potential beneficiaries have expressed a concern that they could be locked into repayment responsibilities, only to have project operations change in the future in a way that reduces or eliminates their anticipated benefits. Providing assurances to beneficiaries that projects will be operated as determined prior to implementation might help beneficiaries feel more comfortable in coming forward and helping to identify their likely benefits, but it could also reduce operational flexibility for projects to adapt to changing future conditions.

Through the process of cost apportionment, some costs may be assigned to the public as a whole for repayment. Historically, the State of California has used public funds to pay for a large number of water resource projects, as has been the case through the first five years of the CALFED Bay-Delta Program. However, local agencies also have played an important role in financing water projects in addition to State and federal participation. As federal and State funds allocated to water related projects have become diminished, and as local groups continue to improve their capabilities and expertise in planning and financing, the share of local financing may well increase. There has also been a growing movement to ensure that public moneys are not used to create unfair advantages for private interests, especially when those advantages come at the expense of taxpayers.

Because of the public’s expectation that public funds will be used wisely, a benefits-based approach may be more effective by focusing public investments toward actions that lead to public benefits. Just as the characterization of project benefits is important for cost-benefit analysis and repayment options, carefully deciding what positive outcomes from a project should be classified as public benefits can also be a central part of the water resource financing process. Traditionally, public benefits have been associated with features such as ecosystem restoration and other benefits that accrue to a diffuse set of beneficiaries and cannot be attributed to a specific set of beneficiaries. There are other situations, however, that may justify the expenditure of public funds for water resource initiatives even if benefits accrue to a specific set of beneficiaries.

The California Bay-Delta Authority, in its finance planning efforts, developed criteria to help determine when public

<table>
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<tr>
<td>One way that benefits can be described is based on whether they are public or private in nature. Public benefits are generally associated with public goods, which economists have defined as items such as parks, certain types of roads, and national defense, which have two common characteristics:</td>
</tr>
<tr>
<td>1. It is difficult for one person to prevent another from using a public good by using it for their own benefit (i.e. visiting a park does not usually prevent other people from also visiting).</td>
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<tr>
<td>2. It is difficult for the producer of the public good to prevent people who have not paid for it from using it (i.e. a bird watcher can benefit from protection of a bird species, even if they don’t help pay for the protection).</td>
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<tr>
<td>Within the water resource context, public benefits are normally associated with project purposes such as ecosystem restoration, certain types of flood protection, and aesthetic improvements. These benefits can be enjoyed by a large number of people, usually without diminishing the benefit. Since it is difficult to keep individuals from receiving the benefits without paying for them, public goods and their benefits are often paid for using public funds, such as tax revenues.</td>
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funds should be used to pay for projects under the CALFED Bay-Delta Program\(^3\). The list of conditions for spending public money included the following situations:

1. Program actions are expected to yield significant, but very diffuse, benefits that cannot be easily associated with specific user groups.
2. Program actions generate public goods such as environmental protection and enhancement, advancement of scientific understanding, and basic research.
3. Program actions catalyze local investment in new water management approaches and technology.

These three criteria serve as useful guidelines for identifying additional conditions when it may be appropriate to include the public as a beneficiary. As mentioned earlier, under a benefits-based approach it is difficult to assign costs for project features that result in benefits that are not easily linked to particular groups. For those types of projects, the general public has been a key contributor. Environmental, scientific, and research-oriented projects provide a variety of benefits, and all people within the State can potentially gain from those actions. In addition, innovative projects used to develop new technologies and improved methods have also received public funds in the past. There may be other scenarios outside of the three listed above that justify public expenditures for benefits not enjoyed by the larger public, as will be discussed later, but in general, using public funds primarily for water resources projects that benefit the overall public may serve as a useful guideline.

Another factor in determining who should pay for water project costs concerns the economic resources of the beneficiaries. There may be situations where a beneficiary’s ability to pay becomes a factor in water financing decisions, and certain groups with particular financial needs may require assistance. The term \textit{equity} is often used in economics to describe the level of fairness in which taxes impact people with similar ability to pay (horizontal equity) and different ability to pay (vertical equity) capabilities. With respect to water resource financing, equity can be described as the condition where beneficiaries with a greater ability to pay may be required to make a larger contribution to cost repayment than beneficiaries with a smaller ability to pay, given a certain increment of benefit. Under an \textit{equitable} arrangement, a financially healthy city might be expected to pay for the full cost of a 1 million gallon per day (MGD) water treatment plant, while a disadvantaged community might be assigned a fraction of full cost for an identical 1 MGD plant. It may be necessary to turn to the general public to pay for the cost increment above the beneficiary’s ability-to-pay, if it is determined that the need is great enough to justify doing so.

Related to the idea of equity is the concept of \textbf{Environmental Justice}. The U.S. Environmental Protection Agency has defined Environmental Justice as “the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies”. To fulfill the principles of Environmental Justice, projects need to be structured so that benefits are not distributed unfairly to one group over another. For instance, if a project generates flood control benefits for residential areas, lower-income families should be protected in the same way as higher-income families under theses principles. Because of the tenets of

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equity, this may require public funds, contributions from other project beneficiaries willing to pay more than their share of costs in order to enjoy the benefits of the project, or other sources in order to make up for any ability-to-pay deficiencies.

There are two particular groups in California for which equity and Environmental Justice principles may apply in making water resource financing decisions:

1. Disadvantaged communities
2. Tribal governments

For both disadvantaged communities and tribal governments, special considerations may be necessary in determining ways to fund water resource projects. For both groups, State funding may be needed in order to maintain equity in the development of water resources in California. While programs currently exist through which these groups can obtain public water project funds, such as DWR’s Water Use Efficiency Program and the Drinking Water State Revolving Fund, greater effort may be required to ensure that all communities throughout the State are receiving safe and reliable water delivery, water quality, and other water-related services. New targeted programs that focus on these groups may allow for greater access to public funding.

Besides allowing for better access to State funds, these groups may require protection from the impacts of project implementation. Because disadvantaged communities are often located in close proximity to existing and proposed infrastructure projects, they have at times been forced to bear indirect costs of implementation. State and local agencies should work to ensure that these groups are not unfairly treated when decisions are made on project location and configuration. Considerable efforts should be made to minimize the physical, economic, and social disruptions that can result from new water resource projects. Just as many environmental benefits are difficult to quantify in economic terms, the costs associated with community impacts can also be difficult to measure, but that does not diminish the importance of preventing vulnerable groups from suffering unjustly for the benefit of others.

How Will Payments be Made?
Unfortunately for decision-makers, the financing process does not end after it is determined who will pay for the costs. A long list of mechanisms exists for cost recovery, each with its own set of advantages and disadvantages, with the effectiveness of each dependant on the type of water resources initiative involved. Instead of attempting to inventory as many of these techniques as possible, it may be useful to highlight a small number, while discussing a few general ideas related to the payment process. There are many references available which describe these and other methods in greater detail.

Perhaps the most basic, and one of the most important, features of a funding mechanism concerns at what time payments will be made. Methods that require funding in the short term are known as pay-as-you-go options, while those that delay repayment in exchange for greater interest charges fall under the debt financing category. Using State appropriations, which are determined by the Legislature each year, is an example of pay-as-you-go financing, while the use

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of general obligation (GO) bonds, which are often paid off over several decades, is a form of
debt financing. Pay-as-you-go financing is generally viewed as the more fiscally responsible
alternative, as interest payments in the future are reduced or eliminated. Debt financing,
however, can reduce the uncertainties associated with year-to-year funding sources, and can
allow future beneficiaries the opportunity to share in the repayment instead of lumping all cost
responsibilities on the present.

Whether repayment occurs through pay-as-you-go or debt financing methods, and despite the
many uncertainties associated with water project financing, one thing is certain in California –
there is a strong need today for reliable, long-term funding sources. Although public funding
from the State has paid for a large amount of project costs in the past, the current scarcity and
variability of public funds indicate the need for alternative sources. General obligation bonds
can serve as useful tools for funding projects with widespread, public benefits, but over-reliance
on GO Bonds can lead to degradation of the State’s credit rating, unfair subsidization of private
groups, and higher repayment costs for taxpayers in the future. State appropriations also have a
role in financing water resource projects that benefit the general public, but authorization
requirements and the large degree of variability and uncertainty in year-to-year funding also
suggest that alternative sources should be considered.

Identifying new funding sources may require looking more closely at financing tools such as
revenue bonds, which link repayment with future project revenues and have provided a source of
funding for the State Water Project for over four decades. This type of financing method also
adheres to a benefits-based approach, since the project beneficiaries contribute to project funding
using the direct revenues obtained from the operation of the project itself. User fees of some
form may also be a potential alternative, assessing charges based on the quantity of water
diverted, the magnitude of retail water sales, using a fixed monthly fee, or by other methods.
The CALFED Bay-Delta Program has been evaluating various forms of user fees since it was
directed to do so by the 2000 CALFED Record of Decision (ROD), and work continues under
the oversight of the new California Bay-Delta Authority. Some legislators have expressed a
concern that these fees might be crafted more as a tax than a targeted fee, and any proposed user
fee would have to be carefully designed to conform to the beneficiary-pays principle. Local
agencies could also continue to see increasing financial responsibilities as decision makers
attempt to limit public fund expenditures.

A long-term funding source could also be used to help local agencies pay for the costs associated
with developing Integrated Resource Plans. The State of Texas provides state funding for 100
percent of direct planning costs for its Regional Water Plans through a special grant program
administered by the Texas Water Development Board. About $20 million was awarded to the
local agencies in state appropriations through this grant program to fund the first round of
planning, which was completed in January of 2002. In turn, the participating agencies pay for all
of the administrative costs associated with the plans. California could establish a similar
program, funded through state appropriations or other sources, to help provide consistent state
financial assistance for IRP development.
Beyond traditional funding sources and mechanisms, more unconventional strategies could also be used to harness the advantages created through certain forms of water resource partnerships. A few examples of partnering arrangements include the following:

- Infrastructure-for-Water Transfers
- JPA Bond Pool Arrangements
- Public/Private Partnerships

An infrastructure-for-water transfer is a type of financing partnership where one agency transfers a portion of its water supply for new infrastructure improvements that are paid for by another organization. One prominent example of infrastructure-for-water transfers in California took place between Metropolitan Water District of Southern California (MWD) and the Imperial Irrigation District (IID), resulting in canal lining, on-farm management improvements, and other conservation measures in exchange for 106,000 acre-feet of annual supplies for MWD. These improvements often result in increased water efficiency for the group transferring its water, reducing or eliminating the need to seek replacement supplies. The increased efficiency can also limit damaging third-party impacts that can occur when water transfers reduce economic activity in the area of origin. The net result is new water supplies for the group funding the infrastructure work, and improved facilities and higher efficiencies for the agency transferring its water—all potentially without the need for public funds. Infrastructure-for-water transfers can be difficult to arrange because of the institutional and legal requirements that must be followed, but the dividends of completing a transfer can potentially justify the effort.

Joint Powers Authorities are arrangements where two or more agencies come together to share common responsibilities and utilize the coordination and management advantages inherent in JPAs. One particular advantage of a JPA is its ability to pool a number of separate smaller-scale bond offerings into a single financial instrument, resulting in smaller debt issuance costs and greater credit standing in the municipal bond market. JPA bond pool arrangements enable smaller agencies to gain access to debt financing that may otherwise be too costly or unavailable for smaller capital projects. One example of a JPA bond pool arrangement is the Financing Authority for Resource Efficiency of California (FAReCal), which has helped finance water and electricity projects for cities, water districts, irrigation districts, and municipal utility districts throughout California. The benefits of bond pooling through JPAs must be weighed against the loss in local financing control and flexibility that is necessary to form a pool and the potential for credit erosion if too many high-risk participants join the JPA bond pool. In addition, a 1998 interpretation of State law by the California Attorney General set limits on how JPA bond pools could be established and managed, which has removed the ability of some pools, including the California WateReuse Finance Authority, to take on new borrowers or finance additional debt. JPA bond pools may, however, still be created, as long as all participating borrowers are identified before the establishment of the JPA, and other requirements are met.

Another potential form of financing partnership that could be useful for water resource investments involves the use of the private sector to finance, design, construct, and/or operate a

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5 For further information, see “Maintaining Momentum on California Water Issues: Business Leaders’ Findings”, May 1996.
public service facility. The use of public/private partnerships has become more controversial in recent years, particularly following the California energy crisis and with the ongoing litigation over Stockton’s wastewater management, but there could still be potential to use adequately regulated forms of private sector participation to help finance water projects. The most widely identified advantages of public/private partnerships is greater efficiency brought about by competitive market forces and the incentive to innovate business practices. Private sector groups have also been shown to establish lower operating costs than public systems, and can provide more accessible financing for local agencies. Although many factors have been identified as the cause of the Californian energy crisis, the fallout from the event suggests the need for strong regulatory oversight with public/private partnerships. In addition, the fact that many forms of public/private partnerships exist with varying levels of private sector participation shows that there may be potential for smaller-scale private involvement, such as using developer financing to allow private sector financial assistance while maintaining public management and oversight.

Final Thoughts
Beyond the step-by-step procedures involved with water project financing, there are some broad-perspective, policy-related issues that are also important for decision-makers to consider when developing funding strategies.

One aspect of financing decisions to consider is how to balance fiscal and institutional realities against proposals to change and improve conditions in the future. For example, current State water law includes several instances where State and local cost share levels for water resource projects are explicitly identified. A thorough finance investigation might, however, suggest that a different cost share split would more equitably and accurately link benefits and costs to beneficiaries in a beneficiary-pays approach. Similarly, funding investigations may identify large cost requirements that, even with the resulting benefits, could be very difficult to justify given current fiscal conditions. Decision-makers may be forced to choose whether to suggest changes to the legal framework and funding targets that may require new funding sources, or whether the existing framework and fiscal realities should serve as rigid constraints in their funding analyses. On one hand, suggesting changes to current policies could result in attacks that the planners failed to consider actual conditions in their investigation, and as a result ignored the “real world” in the process. On the other hand, by only considering current conditions and existing law, planners may be accused of not thinking “outside-the-box,” lacking innovative and creative ideas, and failing to be proactive in seeking out additional funding sources.

Another factor is the use of transparency in the financing process. In a transparent process, negotiations can take place in a way that may help minimize or prevent the potential for back-door deals and surprise tactics. Transparency involves direct access to the funding discussions by the public, and ensures that all the participating parties are known and held accountable for their actions. While there may be points during the development of a financing strategy where ongoing negotiations require that certain funding discussions take place outside of the public arena, transparency requires that these instances be limited and only allowed when absolutely necessary, and that before any financing decisions are finalized, all allocation and cost sharing arrangements are known and understood.

In the same way that transparency may help with the funding process, *clarity* can also play a key role, by identifying the limitations of the plan or strategy developed and expressing how far along the financing activities have come. Finance plans that are in an early stage should clearly be identified as such, since these preliminary efforts often contain gross assumptions and placeholders that could be very different from what is in the final form. Being clear about a plan’s degree of completion, particularly in a transparent process, may help reduce the chance that early benefit and cost information is misused and misinterpreted – even though that possibility cannot be eliminated. It is almost inevitable that some preliminary number will be pulled out and used by an interest group to make a particular argument, but being explicit about the number’s preliminary status can reduce the significance of these occurrences. Being clear about the intent and limitations of a funding strategy can help ensure that the plan is used and evaluated as intended. For financing efforts aimed at developing a framework that is a tool, and not an end, to be used by policy-makers in making funding decisions, making this fact clear may reduce the chance for misunderstandings. For more finalized finance plans that serve as a more rigid directive for distributing costs and benefits, it will also be beneficial for everyone to understand the plan’s scope and intent. In these and other ways, clarity can be a vital and effective part of successfully funding water resource projects.

There is no single strategy for successfully financing water resource projects. There are, however, some lessons that can be learned from the past, and guidelines that may be useful in making effective future decisions. Given the importance of water to the State of California, the large-scale infrastructure projects now being evaluated, and current fiscal conditions, it will be especially important for decision-makers to consider these factors in the years ahead.
Future Food Production and Consumption in California Under Alternative Scenarios

By Henrich Brunke, Richard Howitt and Daniel Sumner, University of California
Agricultural Issues Center
Future Food Production and Consumption in California Under Alternative Scenarios

By Henrich Brunke, Richard Howitt and Daniel Sumner

University of California Agricultural Issues Center

April 2004

This report considers food production and consumption patterns in California in recent years and the likely pattern of California food production and consumption in year 2030. It also considers in less detail recent production and use of nonfood agricultural products. The purpose of this analysis is to help the California Department of Water Resources respond to legislative requirements concerning information used in considerations about future supply and demand for irrigation water in California.

Introduction

This report was prepared for the California Department of Water Resources (DWR) in its response to California legislation AB2587. A key phrase in the law is that “neither the state nor the nation should be allowed to become dependent upon a net import of foreign food.” In particular, DWR is urged to consider scenarios under which agricultural production in California is sufficient to assure that California is a net food exporter and that the net shipments out of state are enough to cover its traditional share of “table food” use in the United States plus “growth in export markets.”

The law is specified in terms of aggregate food production, consumption and trade on a net basis. The focus on feeding the population in California and “table food” for the United States excludes several of the most important agricultural commodities in California. In particular, cotton and ornamental crops are not food items, but both are important in production value. Cotton ranks second in export value, and ornamental horticulture crops, as a group, generate about $3 billion in farm production value in California. Furthermore, the analysis and projections to consider “net import of foreign food” exclude such livestock feed crops as hay, feed grains and oilseeds.

The main focus of the legislation was on concerns for water available for food production in California relative to food use in California. Consistent with this emphasis, nonfood crops are not included in our full analysis of production and use currently or in 2030. However, we do examine the position of California with regard to ornamental horticulture, cotton, live animals and animal feeds. We note that California uses far more animal feed and more cotton (in the form of clothing and textiles) than it produces, but it is a net shipper of ornamental horticulture, mainly to other states.

The reference to food consumption, production and trade requires a common unit to aggregate the individual food commodities. (It is useless to attempt to create food balances for hundreds of individual commodities. Even if this were feasible, the questions we are addressing and AB 2587 relate to California food as a whole and not to specific products.) Given the nature of food production in California, the only

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reasonable unit for aggregation is the value of each commodity. Aggregation in value terms reflects the
relative weights of these commodities from the viewpoint of buyers. It makes no sense to simply add tons
of apples and tons of oranges or tons of rice and tons of Cabernet Sauvignon. In some very poor
countries, analysis of food supply and demand is done in terms of staple-grain equivalents, where basic
foods are converted to equivalents of tons of rice of wheat. Such an approach may be useful, for example,
in North Korea, but makes no sense in California, where dairy, beef and horticultural crops dominate food
production. We therefore use estimates of the farm value production, consumption, and trade of food
products to calculate the net trade position of California.

Measured by aggregate value, California is a net food shipper to the rest of the United States and the rest
of the world. Besides shipments out of state, there are substantial gross shipments of food and other
agricultural products into California. California food shipments from the rest of the United States and
from international sources are large and vital to the health and welfare of Californians. Furthermore,
imports of such nonfood agricultural commodities as live animals, livestock feed, and crop seed are also
crucial to the productivity of California food industries. The net export trade balance must not obscure the
importance of trade flows in both directions.

This analysis does not consider the nutritional details of available food. We aggregate across food
products using values rather than a single nutritional unit such as calories or vitamins. A far more
extensive analysis would be needed to consider the trade position of California for each major nutrient
component.

Furthermore, we only consider net shipments of food into and out of California. Most food consumed in
the state, including grain products, meat, tropical fruits, and “off-season” produce is produced elsewhere,
and most of the crop production in California, although not the dairy production, is shipped out of the
state. We follow the specific language of AB 2587 in examining net trade flows.

Turning to the supply side, we do not attempt to decompose expected crop yield growth due to aggregate
technological improvement adopted in California into specific technological changes. It is very difficult to
forecast the rate at which new technologies will be adopted and essentially impossible to project the path
of applicable research itself. Such crop yield improvements have occurred steadily for decades, but we
have not attempted to project which innovations will be adopted over the next three decades.

We do not explicitly consider irrigation water supply or demand. As specified below, we do consider a
reduction of overall cropland with a shift to urbanization. This implies a shift of the irrigation water now
associated with that cropland. Our analysis does not explicitly model changes in the current irrigation
water situation. For example, we do not estimate the state of snow packs or reservoir levels. Nor do we
explicitly consider the position of ground water availability into the future. Our analysis implicitly holds
irrigation water use per unit of cropland constant. We incorporate explicit growth in output per unit of
land. This implies growth in output per unit of irrigation water, but we do not include any further
reduction in irrigation water use per unit of land. There have been declines in water use per acre in
California for many crops, but we, conservatively, do not project those to continue.
Section 1. Interpretations and Analysis of Current Data

We first calculated the current position of California food consumption, production, net shipments to the rest of the United States, and net shipments to export markets. Table 1 shows approximate values for five food categories and for the sum of those commodities. The food categories include approximations for most of U.S. food and beverage production and consumption. We exclude some processed product trade and some minor food items. We also do not include fish consumption.

Base Data and Methods

The first step was to determine a base period for California production. The California production data used was reported in the 2002 CDFA Resource Directory, which lists California production data for 2001 that is taken from data produced by the National Agricultural Statistics Service (NASS) of USDA. In 2001, California vegetable production was valued at $6.1 billion, and California fruit and tree-nut production was valued at $7.0 billion, for a combined value of $13.1 billion. The next category “Food Grains” is comprised of rice and wheat. The 2001 value for wheat was $112 million. The 2001 production value of $138 million reported for rice in the 2002 CDFA Resource Directory was inconsistent with other reports, so we used the $203 million value of production figure reported directly by the California office of the National Agricultural Statistical Service (CASS). Combining the rice and wheat values yielded a $315 million value of production for food grains. The value of production of milk and cream was $4.63 billion in 2001. Remaining livestock (primarily beef) and poultry (including eggs) totaled $2.72 billion in 2001. Other food products, including oilseeds, sugar and sweeteners, and spices totaled $103 million in 2001. Thus, the total value of California food production in 2001 was $20.5 billion at farm gate value.

Next, we turned to consumption for 2001. We obtained the total U.S. consumption for the five categories by adding the value of U.S. imports of goods for each category to the value of U.S. production of goods for each category and then subtracting the value of exports of the goods from each category.

Data for the value of U.S. production was obtained from the NASS. For example, U.S. food grain (wheat and rice) production value totaled $6.37 billion in 2001 ($5.44 billion for wheat and $925 million for rice). Trade data for the United States is based on the Foreign Agricultural Service’s FATUS database. According to these data, the United States exported $4.02 billion worth of food grains ($3.33 billion for wheat, unmilled and $692 million for rice, paddy) in 2001. At the same time, the United States imported $450 million worth of food grains ($169 million for rice and $281 million for wheat). The production values here are at the farm gate. The trade data are at port and, therefore, includes some post-farm value added. The estimate of post-farm gate value added varies widely across products (Bervejillo and Sumner). Unfortunately, there are no estimates available of farm value of imports or exports.

Applying the formula for consumption (production + imports – exports), we obtained a $2.8 billion total for U.S. consumption of food grains in 2001. Using similar procedures, U.S. consumption for fruit, tree nuts and vegetables was $29.4 billion in 2001. Milk and cream consumption in the United States was $25.5 billion, livestock and poultry consumption totaled $72 billion, and other food product consumption was $10.2 billion. Total U.S. consumption of food commodities was approximately $140 billion in 2001.

Because California data was unavailable, California consumption was derived from U.S. consumption data using the approximate California share (12 percent) of the national population. At the level of
precision available for other parameters and estimates, this approximation is appropriate. We assumed that consumption patterns in California were similar to those in the rest of the United States. California population in 2000 totaled about 34 million, and the U.S. population was about 282 million. Applying 12 percent to total U.S. consumption of the individual commodity groupings yielded a California consumption figure of $3.5 billion for fruits, tree nuts and vegetables, $338 million for food grains, $3.1 billion for milk and cream (dairy) products, $8.6 billion for livestock and poultry, and $1.2 billion for other food products. Total California consumption of food commodities totaled $16.8 billion in 2001.

The USDA Economic research service (Lin et al.,) provide detailed analysis of how per capita consumption of food differs across the United States by region, ethnicity and other demographic factors. In addition, we could have made adjustments for the slightly higher average personal income in California and for differences in relative prices. We found in our preliminary analysis that none of these adjustments was large for food aggregates and some were offsetting, so we expect the consumption figures that we calculated are close to the true, but unavailable, figures. Notice that all these calculations are done on a farm value basis or port value for imports and exports and do not include the value of the farm-to-retail markup. For the livestock data, we have taken into account that meat animals are often exchanged in farm-to-farm transactions before the final sale to food processors.

Next, we looked at California trade. Export data was obtained from the AIC database on California’s agricultural exports. Given the base data on exports we used export values that included some value that was added after the product left the farm. Rice exports in 2001, for example, totaled $166.4 million, and California wheat exports were valued at $3.9 million. Thus, the total for the food grain category was $170.3 million. Export figures were also obtained for the other food categories in the study. Note that California does not export food commodities included in the category “other food products.” Vegetable oils, peanuts, sugar and sweeteners, and spices are mainly produced in other parts of the United States or not produced in the United States at all.

There is no database for imports by state in the United States, but data are available for the nation as a whole (see above). To get a reasonable approximation of California imports of food commodities, we again applied the 12 percent population share. Taking the example of food grains, we estimated that the California value of such imports for 2001 was $54 million (12 percent of $450 million in U.S. food grain imports). We derived California import values for the other food commodity categories in the same manner.

**Base Position of California Food Production, Consumption of Trade in 2001**

From the production and consumption values for food commodities in California, we can derive the net position of California agriculture. Subtracting California consumption from California production yields the value of California production available for consumption in the rest of the United States or for international export. These data are reported in Table 1. As expected, California was a net exporter of fruit, tree nuts and vegetables ($9.6 billion), a net importer of food grains ($25 million), a net exporter of dairy products ($1.6 billion) and a net importer of livestock and poultry ($6.3 billion) and other food products ($1.1 billion). For food commodity production, California was a net exporter by $3.6 billion in 2001.
Now consider the net trade position of California food commodities with the rest of the world. California was a net exporter of $2.5 billion in fruit, tree nuts and vegetables to the rest of the world in 2001. California food grains and the dairy industries also had net foreign trade surpluses in 2001. California, however, is a net importer of livestock and poultry and other food products.

After obtaining California’s net position regarding the production and trade of food commodities, we were able to derive the net trade position of California with the rest of the United States by subtracting California net trade with the rest of the world from California’s net production (production minus consumption). The results are in the last row of Table 1. The second to last row in Table 1 shows U.S. consumption minus California consumption.

The first three rows of Table 1 show the production, consumption and net surplus position of California for each of the food categories. Row one shows the value of California production of each food category and a total production value of just over $20 billion. This is a probably a small overstatement of California’s food production value because it includes the value of hides and skins and wool. As noted above, California consumption values are approximated by assuming that California consumes 12 percent of the national total disappearance of each category (based on California’s share of national population).

The international export position of California agriculture is shown in the rows 4–6 of table 1. Most food exports are in the fruit, tree nuts and vegetables category, and because of the large export surplus in this category, California is a net exporter of food value.

To consider the position of California relative to the food consumption of the rest of the United States outside California and to the United States as a whole, we estimated the farm value of U.S. food consumption and the farm value of U.S. food consumption outside California (RoUS). Total farm value of U.S. food consumption at is about $140 billion, with about 12 percent ($16.8 billion) of that in California. California production of food accounts for about 14.6 percent of total U.S. food consumption ($20.5 billion California production/$140 billion U.S. consumption) and about 14.4 percent of U.S. food production ($20.5 billion California production/$142.5 billion U.S. production). On a net basis, California production could cover California consumption plus another 2.6 percent of food consumption in other states.

California exports valued at the port equal about 21 percent of food production valued at the farm. The AIC estimate is that California exports average about 18 percent of the production by quantity for 50 main export commodities (Bervejillo and Sumner 2003). Thus, their estimate is that on average port value is about 16.7 percent higher than farm value for the main California export products. We estimate that international imports are about 14 percent of food consumption in California.

Also note the 14.6 percent share of California production in U.S. food consumption at farm (or import) value is higher than California’s share of U.S. agricultural production overall because California produces relatively little feed crop value, no tobacco, and a small share of energy crops (mainly corn for ethanol). California is a net exporter of food to the rest of the world on a net basis.
Table 1
Farm Value and Border Values of Food Commodity Production, Consumption and Trade for California and the United States, 2001, in Million Dollars

<table>
<thead>
<tr>
<th></th>
<th>Fruit, tree nuts, vegetables</th>
<th>Food grains (rice and wheat)</th>
<th>Dairy</th>
<th>Livestock and poultry</th>
<th>Other food products1</th>
<th>Total2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calif. production</td>
<td>13,100</td>
<td>313</td>
<td>4,630</td>
<td>2,300</td>
<td>103</td>
<td>20,446</td>
</tr>
<tr>
<td>Calif. consumption2</td>
<td>3,527</td>
<td>338</td>
<td>3,061</td>
<td>8,643</td>
<td>1,233</td>
<td>16,802</td>
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<tr>
<td>Production – consumption</td>
<td>9,573</td>
<td>-25</td>
<td>1,569</td>
<td>-6,343</td>
<td>-1,130</td>
<td>3,644</td>
</tr>
<tr>
<td>Calif. RoW3 exports</td>
<td>3,658</td>
<td>170</td>
<td>340</td>
<td>180</td>
<td>0</td>
<td>4,348</td>
</tr>
<tr>
<td>Calif. RoW imports</td>
<td>1,176</td>
<td>55</td>
<td>207</td>
<td>516</td>
<td>430</td>
<td>2,384</td>
</tr>
<tr>
<td>Net Calif. with RoW trade</td>
<td>2,482</td>
<td>115</td>
<td>133</td>
<td>-336</td>
<td>-430</td>
<td>1,964</td>
</tr>
<tr>
<td>Total US consumption5</td>
<td>29,394</td>
<td>2,820</td>
<td>25,507</td>
<td>72,023</td>
<td>10,279</td>
<td>140,023</td>
</tr>
<tr>
<td>RoUS4 consumption</td>
<td>25,867</td>
<td>2,482</td>
<td>22,446</td>
<td>63,380</td>
<td>9,046</td>
<td>123,221</td>
</tr>
<tr>
<td>Net Calif. with RoUS trade6</td>
<td>7,091</td>
<td>-141</td>
<td>1,437</td>
<td>-6,007</td>
<td>-700</td>
<td>1,680</td>
</tr>
</tbody>
</table>

Sources: US Bureau of the Census, USDA-NASS, USDA-ERS, UC-AIC and author calculations.

Notes:
1. Includes vegetable oils, peanuts, sugar and sweeteners, coffee, tea, and spices
2. Calculated as 12 percent of the U.S. consumption value of these items based on the California share of U.S. population.
3. RoW stands for rest of world.
4. RoUS stands for the rest of the United States.
5. Consumption is measured as U.S. production minus exports plus imports.

California Production and Use of Cotton, Animal Feeds and Ornamental Horticulture

California is a significant producer of cotton and, given its large population, a large user of cotton. U.S. consumption of cotton in the form of apparel and textile products totaled about 10.7 billion pounds in 2001. Raw cotton production in the United States totaled 9.7 billion pounds. Exports of raw cotton were about 5.3 billion pounds, while imports of raw cotton were not significant. The United States was a net importer of apparel and textile products, with net imports of 6.3 billion pounds. Based on California’s population share of 12 percent of the national total, Californians consumed approximately 1.4 billion pounds of cotton in 2001. California production of cotton was approximately 0.99 billion pounds in 2001. Hence, California consumption of cotton exceeds production by approximately 0.4 billion pounds. California’s net shipments from overseas and the rest of the United States are about 29 percent of consumption. (Sources for production and trade data of cotton and apparel and textile products were USDA Economic Research Service Reports on “Cotton and Wool Outlook.”)

California uses substantial quantities of grain and protein supplements in the dairy, poultry and beef industries and produces relatively little of this animal feed. California is also a large producer and consumer of hay. The U.S. Customs Service tracks international exports and imports of feed grains, alfalfa, and other animal feeds, but no data are available for shipments within the United States. To approximate the use of animal feed in California, we approximated data on the number of marketable feed-consuming animal units in California. For animal feeds, we included soybeans, sunflowers (non-oil), all hay, corn (grain and silage), oats, rye, barley and sorghum. We did not include pasture feed and
attempted to exclude livestock fed on pasture. We included dairy and beef cattle, swine, poultry, sheep and horses. (We omitted beef bulls, beef cows and calves, and some sheep, which are primarily pasture based). Of the livestock we included, California feeds approximately 5.1 percent of the national herd. In dollar terms, the value of California feed production is approximately $1.1 billion. The value of U.S. feed production is approximately $46 billion. Taking into account U.S. international trade of animal feeds, the use of feed in the United States is about $35 billion. California uses about $1.8 billion worth of animal feed ($35 billion times 5.1 percent). Hence, California produces about 61 percent by value of its use of animal feeds and imports about 39 percent ($700 million), of its total animal feed from the rest of the United States and overseas. The share of 61 percent may be a slight overestimate because the value of U.S. feed trade used here already includes the value of California exports. However, there is no source of the value of exports at the farm gate.

(The sources for the data on California animal feeds are the CDFA 2002 Resource Directory, which provided 2001 data on the number of animals on California farms. The animal unit conversion factors are generally accepted and were obtained from USDA. The value of production for California and U.S. feed commodities was obtained from NASS/CASS. For U.S. trade, we used the United States International Trade Commission database, which uses export and import data as compiled by the U.S. Customs Service.)

In 2001, U.S. consumption of ornamental horticulture products was about $8.5 billion, and California consumption was approximately $1.1 billion based on its population share of approximately 12 percent. The value of production of ornamental horticulture in California was approximately $3 billion. Exports to the rest of the world were only $40 million, which leaves California as a net shipper of ornamental horticulture to the rest of the United States of about $1.9 billion. (Value of production for California nursery/flower crops was derived from the CDFA 2002 Resource Directory. Production value data for the United States came from NASS reports on nursery crops and ornamental horticulture.)

**Section 2. Projections to 2030**

Projections for consumption were used to calculate the production such that California produces food sufficient for continued net export to the rest of the United States and foreign destinations (as discussed in AB 2587). These are discussed and followed by production projections.

**Consumption Projections**

Total food consumption in developed countries rises mainly with population growth. In the United States, the amount of consumer food value that is added off the farm has risen rapidly with income growth. Farm value of food consumption has also risen with income, but more slowly. Changes in the age and ethnic distribution of the population and changes in relative prices affect consumption patterns for specific food products. These are much less important for aggregate foods or large categories.

U.S. population is projected to grow by 24 percent, from 282 million to 351 million people, from 2000 to 2030 (U.S. Census Bureau). California population is projected to grow by 52 percent, from 34 million to 52 million people, during the same period (California Department of Finance). We use these figures as applicable to 2001 to 2030 and thus slightly overestimate demand growth relative to these sources. Real
per capita personal income is expected to grow slowly over this period, and California will become more Hispanic and more Asian.

Recent research from the USDA Economic Research Service projects per capita consumption to grow by about 10 percent for fruits, nuts and vegetables, grow by about 2 percent for grains, fall slightly for dairy, fall by about 3 percent for meats, and remain constant for the other category (Lin et al., 2003). The USDA study looked at consumption patterns for the year 2020. We extrapolated their projections to 2030.

Overall per capita food consumption rises about two percentage points over 30 years. The figures apply to California and to the United States as a whole. Combining population growth with per capita growth, we get the projections shown in Table 2 for overall food consumption and by category.

The percentage projections in Table 2 are multiplied by the 2001 consumption numbers in Table 1 to project consumption value for California agriculture in 2030. We compare these projections to projections of production to establish projection of net shipments out of California.

### Table 2

<table>
<thead>
<tr>
<th></th>
<th>California</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit, nuts and vegetables</td>
<td>62</td>
<td>34</td>
</tr>
<tr>
<td>Food grains</td>
<td>54</td>
<td>26</td>
</tr>
<tr>
<td>Dairy</td>
<td>51</td>
<td>23</td>
</tr>
<tr>
<td>Meats</td>
<td>49</td>
<td>21</td>
</tr>
<tr>
<td>Other</td>
<td>52</td>
<td>24</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>54</strong></td>
<td><strong>26</strong></td>
</tr>
</tbody>
</table>

**Projecting California Agricultural Production to 2030**

Food production changes in California will derive primarily from the following six sources. Relative prices of food and the relative price across commodities affect all of these adjustments and are affected by them.

**Agricultural Land**

Agricultural land (or farmland) in California has been gradually shifting to urban or other nonagricultural uses. Recent analysis has shown that population growth and nonagricultural forces drive such development. About 500,000 acres were converted from agricultural to nonagricultural uses from 1990 to 2000 (Kuminoff, Sokolow and Sumner). We follow Kuminoff, Sokolow and Sumner and use standard U.S. government definitions of farmland that include pasture used for livestock grazing. Furthermore, we note that the U.S. government definitions also include a category of cropland used for grazing to reflect land that has and could be used for crops, but is at the time of a survey used for livestock grazing. Some irrigated cropland is also be used for pasture.

From 1990 to 2000, California population grew by 4.1 million and is projected to grow by about 17 million from 2001 to 2030, which is equivalent to about 5.7 million per decade. If farm to urban
conversion increases at the same rate for each additional Californian as it did in the 1990s, approximately 695,000 acres of California farmland will be converted to urban use per decade. At this rate, the total conversion of farmland from 2000 to 2030 will be about 2.1 million acres. According to the U.S. Census of Agriculture, between 1992 and 1997, the most recent data available, approximately 1.3 million acres were shifted out of farming and ranching in California, but about 0.8 million acres of cropland and 1.1 million acres of irrigated land were added.

If current patterns continue, the land converted will be a combination of irrigated cropland, nonirrigated cropland and pasture. Irrigated farmland acreage (irrigated cropland and irrigated pasture) in California in 2001 was about 9 million acres or approximately 31 percent of privately owned agricultural land in California. If irrigated cropland were shifted to nonfarm uses at the same rate as all cropland, then, under this scenario, approximately 690,000 acres of irrigated cropland in California would shift to nonfarm uses during the 30-year period. As in the past, the expanded use of multi-cropping of irrigated cropland is expected to offset some of the loss in irrigated acres. From 1994 to 2000, the increase in multi-cropping acreage almost offset the decrease in irrigated cropland acreage (Hawkins 2003). Even if only 50 percent of the loss in irrigated acreage is offset by multi-cropping, the net effect of the combination of shifting acreage and multiple use of cropland is a net loss of 345,000 acres from irrigated cropland use over the next 30 years.

Overall, we project that a maximum of 10 percent of California farmland, including both cropland and grazing land will be shifted out of agriculture by 2030.

**Labor**

Changes in farm labor availability depend on policy, demographic, economic growth outside of agriculture, and trends in Mexico. Labor use also depends on technical changes that increase productivity of labor. Such factors as immigration policy, education of farmers and farm workers, and the standard of living in Mexico also affect the cost and productivity of human capital on farms. Long-term trends suggest higher costs of hired farm labor, but higher productivity of all human capital in farming. We expect current trends to continue and that labor availability will not limit production of California agriculture, though real labor costs will rise.

**Regulations**

Environmental, labor and other business regulations have continued to become more stringent over time. We expect this trend to continue. Regulations have affected land use in agriculture and productivity growth. In that sense, they are incorporated in the resource use and yield growth estimates. Government agricultural policy also affects farm production by affecting the relative income from alternative crops through subsidy. Most California commodities receive little subsidy or protection. Feed grains, wheat, rice, cotton, sugar and dairy are major exceptions. Producer support estimates (PSEs) as a share of production value for important California commodities show that certain commodities receive substantial support, while others receive close to nothing. Estimates by Sumner and Brunke (2003) show that the average PSE is approximately 11 percent across all California commodities. Producer support has recently been very high for rice at over 70 percent and sugar beets at over 65 percent. Cotton and wheat PSEs are also far above the average. Dairy, the state’s most important agricultural sector in terms of market value, has a PSE of more than 30 percent. Fruits and nuts, vegetables and melons, and flower and nursery products have PSEs in the low single-digit range. Current trends are for the production effects of subsidies to decline over time and for trade protection from imports to be reduced. Continuation of these
trends would be required for the United States itself to comply with U.S. proposals in international trade negotiations. With reduced production enhancing incentives of farm subsidies, land will shift from rice, sugar beets, wheat, feed grains and cotton to less subsidized crops. The result will be more food value produced in California. The trend for dairy is mixed because relaxation of the dairy subsidy will shift U.S. dairy production toward California, and with trade agreements, the world prices for dairy products will rise. We expect little change in California dairy production if subsidies are relaxed. Changes in farm subsidy may also facilitate acreage shifts.

**Acreage Shifts Across Crops**

Acreage shifts across crops in California have accounted for substantial gains in the value of food production. For example, barley acreage has declined over the past 30 years and cotton acreage has declined over the past 20 years (after an increase in the 1970s). Acres of grapes, almonds and other horticultural crops have increased. Significant potential remains for continued acreage shifts. We would expect these shifts to continue, as demand growth and California’s comparative advantage will continue to favor expansion of fruits, nuts and vegetables over the next 30 years. The total acreage of vegetables, fruit and nuts in California was about 3.9 million acres in 2002. Acreage for cotton, alfalfa and irrigated pasture was about 2.8 million acres in 2002. As the demand for California vegetables, fruit and tree nuts grows, cotton, alfalfa and irrigated pasture acreage in the state is likely to shift toward these crops. Furthermore, California has 20 million acres of non-irrigated pastureland and non-irrigated cropland and 6.9 million acres of pastureland in the Central Valley (Kuminoff, Sokolow and Sumner, 2001). As relative prices and policy adjustments continue to favor the shift of resources, there will be a gradual increase in the value of food production in California. A 10 percent increase in the value of food production from acreage shifts is a conservative estimate.

**Climate Change and Environmental Resources**

Yield growth per acre of land has been a key factor in expanding California agricultural production. Consider first projected effects of climate change over the next three decades. The best estimates available for California crops indicate that climate change over the next three decades will increase yields by an average of 15 percent for major California crops (Adams, Wu and Houston, 2003). Additional references on climate change can be found in Mendelsohn, Nordhaus and Shaw, Adams et al. and Segerson and Dixon.

The average we use is smaller than the increases in yields expected as a consequence of climate change for such important California food commodities as grapes, tomatoes and almonds. Wine grape yields, for example, are expected to increase due to projected climate change by 34 percent by 2030. The projected yield increase due to climate change is 40 percent for almonds. (Appendix C provides more information on the projected effects of climate change on crop yields per acre for food crops in California.) Other resource changes are air quality and soil quality. Despite some crop and location specific adjustments, we see no trends that suggest major reductions in productivity from changes in these resources. We do not discuss water availability here in this context.

**Crop Yields and Technical Change**

Growth in the quantity of food crop production per acre of land will continue to be an important driving force in increasing the value of California food crop production over the next three decades, as it has been in previous decades.
We base our analysis of crop yields on historical yield growth data from 1960–2002. Using these data, we created a yield index for each of 30 California food crops. We then aggregated these indices into an overall California crop yield index using the value share over the period 1997–2001. Using these data, we calculated that the mean percentage rate of growth in the aggregate food-crop yield index over the period 1960–2002 was 1.42 percent per year. This number simply says that over a 42-year period of year-to-year yield changes, the simple average of percentage changes was 1.42 percent per year.

Alternatively, we examined several trend lines fit to the aggregate food-crop yield index and to yield indices for individual crops. The log-linear trend line for the aggregate food-crop yield index has a slope coefficient of 1.11 percent. Table 3 lists the log-linear trends for individual commodities or commodity groups for 1960–2002, which differ considerably across crops. These log-linear trends are also measures of percentage changes over the period.

In table 3, vineyard crops are the most important commodity group in the overall index. The relatively low yield growth can be explained by trends in the industry to lower producing, higher quality varieties and to technologies that limit yield while improving quality. The growth rate for vineyards, therefore, does not seem to represent slow technical improvement.

In our projections to 2030, we used an average yield growth for California food crops of 1.20 percent per year, which we think is conservative. Compounded over 30 years, the total growth rate is 43 percent. Such growth relies on technological advances and the application of such advances in California. It also relies on managerial improvement and innovation on the part of growers. One part of this equation that raises concern is the potential for a failure to invest in agricultural science in California. However, given the long time lags from scientific innovation to productivity growth, we are confident in our conservative productivity growth estimate being met or exceeded.

Table 4 summarizes the base production projections

The growth in California food consumption and shipments to the rest of the United States can now be projected using the base data in table 1 and the consumption and production projections to 2030. Appendix B contains a sensitivity analysis of certain parameters used here.

Table 5 uses the data and projections from tables 1, 2 and 4 to compare food production and consumption for the year 2030. As in previous tables, we aggregate across individual food products using value terms. Column A in table 5 presents the “use” of 2001 California production of food commodities. California food consumption equaled 82.2 percent of California food production in 2001. Shipments to the rest of the United States accounted for 8.2 percent of California production. Net exports to international markets equaled 9.6 percent of 2001 California production (Table 5a). These three shares are obtained from the production and consumption figures presented in table 1. Column B in table 5 contains the proportional change in consumption due to demand growth following population increase. The figures for California consumption and consumption in the rest of the United States are obtained from table 2. Column C of table 5 shows that California food production must grow by 46.5 percent from 2001 to 2030 (44.4 percent for California and 2.1 percent for the rest of the United States) in order to hold both the ratio of California food consumption to California food production and the ratio of rest-of-the-U.S. food consumption to California food production constant at the 2001 values.
However, the total projected growth in California food production value by 2030 equals 58 percent (table 4). The difference between this growth in production and the growth in demand in California and the rest of the United States is 11.5 percent, which is the share in the growth of California food production that will be available for international exports in 2030. This implies that international exports by the year 2030 will grow by 20 percent compared to 2001 (11.5 percent divided by 9.6 percent, table 5a). A further underlying assumption in this analysis is that market forces are allowed to operate in both input and output markets for California agriculture. In particular, if market prices for farm output fall faster than costs fall in real terms, given productivity growth in California, land prices may decline, but land will remain in production. We do not expect significant amounts of land suited for food crops in California to be removed from production over the next 30 years except that portion that is converted to urban uses. Appendix B looks at these findings in more detail and provides estimates for alternative growth rates in production.

Table 6 summarizes the projected growth in inflation adjusted value terms and shows the production and distribution of California food in 2030 compared to 2001.

Conclusions

Tables 4 to 6 summarize the projections and net effects of several changes in California food supply and demand over the next 30 years. The projections shown here rely on some tentative data and assumptions and may change as more data and fuller analysis become available. However, it is unlikely that the dominant driving forces for both production and consumption discussed above will change significantly. As a result, the major findings shown in tables 4 to 6 are unlikely to change substantially. The main conclusion that can be drawn from tables 4 to 6 is that California agriculture will continue to produce substantial quantities of food crops. Furthermore, crop shifts and the productivity growth of California agriculture suggest that the value of California food production will more than keep up with rising population and income growth in California and the rest of the United States. A 10 percent net loss of farmland and irrigation water resources will be more than offset by shifts toward crops with high value per acre, growth in production per acre due to technological improvement, and yield growth attributable to climate change. These productivity growth factors will likely enable California agricultural production to expand such that the inflation-adjusted farm gate value of net food exports to the rest of the world will expand, not contract.
Table 3
Log-Linear Trend Growth Rates for Yield Per Acre for Major California Food Crops and Crop Groups, 1960-2002

<table>
<thead>
<tr>
<th>Crops</th>
<th>Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1.80</td>
</tr>
<tr>
<td>Rice</td>
<td>1.35</td>
</tr>
<tr>
<td>Proc. Tomatoes</td>
<td>1.75</td>
</tr>
<tr>
<td>Fresh Tomatoes</td>
<td>1.20</td>
</tr>
<tr>
<td>Cucurbits</td>
<td>1.17</td>
</tr>
<tr>
<td>Other Vegetables</td>
<td>1.01</td>
</tr>
<tr>
<td>Almonds/Pistachios</td>
<td>2.33</td>
</tr>
<tr>
<td>Other Deciduous tree crops</td>
<td>0.82</td>
</tr>
<tr>
<td>Subtropical crops</td>
<td>0.72</td>
</tr>
<tr>
<td>Vineyard crops</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Table 4
Changes in California Food Production 2001–2030, in Value Terms

<table>
<thead>
<tr>
<th>Source</th>
<th>Percent change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical change (1.2% per year)</td>
<td>+ 43</td>
</tr>
<tr>
<td>Climate change yields growth, yield/acre</td>
<td>+ 15</td>
</tr>
<tr>
<td>Crop shifts</td>
<td>+ 10</td>
</tr>
<tr>
<td>Land loss to urbanization and other</td>
<td>- 10</td>
</tr>
<tr>
<td>Net production change</td>
<td>+ 58</td>
</tr>
</tbody>
</table>

Table 5
Projected Growth in California Food Consumption and Exports 2001–2030, in Value Terms

<table>
<thead>
<tr>
<th>Year 2001 % of California Production</th>
<th>Proportional Growth from 2001 to 2030</th>
<th>Growth in California Food Supplies to Satisfy Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>California Consumption</td>
<td>82.2%</td>
<td>0.54</td>
</tr>
<tr>
<td>Rest of US Consumption</td>
<td>8.2%</td>
<td>0.26</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Based on table 1, last column.
2 Based on table 2, bottom row.

Table 5a
Derived Growth in California International Exports

<table>
<thead>
<tr>
<th>Year 2001 % of California production</th>
<th>Derived proportional growth from 2001 to 2030</th>
<th>Growth in California food supplies available for international exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoW net exports</td>
<td>9.6%</td>
<td>1.20</td>
</tr>
</tbody>
</table>

1 Based on table 1, last column.
2 Difference of net production change (table 4, bottom row) and growth in California food supplies to satisfy increase in California and U.S. demand (58%, table 4, bottom row).
<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>Growth factor</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>California production</td>
<td>20,446</td>
<td>0.58</td>
<td>32,305</td>
</tr>
<tr>
<td>California consumption</td>
<td>16,802</td>
<td>0.54</td>
<td>25,875</td>
</tr>
<tr>
<td>Net RoUS exports</td>
<td>1,680</td>
<td>0.26</td>
<td>2,177</td>
</tr>
<tr>
<td>Derived RoW net exports</td>
<td>1,964</td>
<td>1.20(^1)</td>
<td>4,313(^1)</td>
</tr>
</tbody>
</table>

\(^1\) Derived as a residual.
References


California Department of Food and Agriculture. “2002 Resource Directory.” Available at: www.cdfa.ca.gov/card/card_new02.htm


Appendix A. Value Per Unit of Irrigation Water

Irrigation efficiency has been improving for decades with better technologies available and more adoption of these technologies. For example, more use of drip and sprinkler irrigation has led to less incidental evaporation per unit of applied water. In addition, in California there has been a shift to commodities that produce more crop value per unit of water. From 1972 to 1995, total acre-feet of irrigation water use in California has increased only slightly. The gross value of production per acre has increased substantially. Gross value of production per acre-foot has increased even more (Table A.1). In 1972, California agriculture generated $185 nominal terms per acre-foot of irrigation water applied ($576 in 1996 dollars using the GDP deflator (Implicit Gross Domestic Product Price Deflator)) or $375 in 1996 dollars using the index of prices received by farmers. In 1995, nominal value per acre was $672 per acre-foot in nominal terms, ($687 per acre-foot in 1996 dollars using the GDP deflator and $721 in 1996 dollars using the index of prices paid by farmers). The growth in value per acre-foot of water was 264 percent over these 23 years using the nominal values, 19.3 percent using values deflated by the GDP deflator and 92.6 percent using values deflated by the prices received by farmers index.

<table>
<thead>
<tr>
<th>Year</th>
<th>Nominal</th>
<th>Deflated by GDP deflator</th>
<th>Deflated by prices received by farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>185</td>
<td>576</td>
<td>375</td>
</tr>
<tr>
<td>1995</td>
<td>673</td>
<td>687</td>
<td>721</td>
</tr>
</tbody>
</table>

Percent change 264 19.3 92.6

Table A.1
Changes in Dollar Value of Production Per Acre Foot of Applied Water

Source: California DWR, U.S. Bureau of Economic Analysis (GDP deflator used with 1996=100), USDA-ERS.
Appendix B. Sensitivity Analysis

The most important factors affecting production growth are growth in yield per acre attributable to technical change and growth in yield per acre attributable to climate change. In order to provide information on the robustness of these factors, sensitivity of the results to changes in these factors is presented in this appendix.

According to table 4 in the main text, California would need to supply 44.4 percent more food by the year 2030 to meet its current ratio of California food consumption to California food production. Another 2.1 percent increase by 2030 would be necessary to maintain the current ratio of rest-of-the-U.S. food consumption to California food production. The additional food supply from the main sources totaled 58 percent, which would be more than enough to meet 2030 net food requirements in California and California’s share to the rest of the United States under our baseline scenario.

We now look at a range of the parameters that contribute to the change in California’s food production by 2030. Two essential parameters are the impact of technical change and the impact of climate change on future food supply. Our baseline scenario, which is based on an econometric analysis of yield data from 1960–2002, uses an annual growth rate in output/acre of 1.2 percent attributable to technical change. We also attribute 15 percent yield growth over 30 years to climate change. This appendix investigates alternative annual growth rates attributable to technical change and to climate change.

Table B.1 presents the results for three alternative rates of growth attributable to technical change and three alternative growth rates attributable to climate change. Assuming a high technical growth rate of 1.4 percent per year, together with the other base assumptions, the total growth in production over 30 years equals 66 percent. This scenario leaves room for a large expansion in international food exports from California. Assuming a lower annual growth rate attributable to technical change of 1 percent, the resulting overall growth in California food production totals 49 percent from 2001 to 2030. Population growth in California and the United States require California food production to increase by 46.5 percent to keep the net contribution to food supply constant. This leaves a surplus of 2.5 percent, which can be used for California international net exports of food commodities. The next row shows the minimum growth in technical change necessary to meet the increased demand for food in California and to the rest of the United States in the year 2030. In order to meet that criterion, output per acre would need to grow by 31.5 percent over 30 years, which is equivalent to an annual growth rate of 0.9 percent.

In the lower half of table B.1, we apply the same kind of sensitivity analysis to three scenarios about the effects of climate change on production of food in California. Our baseline scenario uses a 15 percent growth in the value of food production as the consequence of climatic change over the period 2001-2030. Table B.1 shows the impacts on California food production in 2030 and net food balances, if the impact of climatic change is 20 percent or 10 percent. With a 20 percent growth in yields attributable to climate change the total production increase is 63 percent from 2001 to 2030, and international food exports increase substantially. If instead climate change causes only a 10 percent yield increase, the net international exports decline compared to the base scenario.
With the same base values for other parameters, a yield growth due to climate change of only 3.5 percent implies that growth in productivity equals growth in demand in the United States and in the rest of the United States. Table B.1.b is presented in the same format at table 5.a in the text. Table B.1.b presents the derived growth in food supplies available for international exports under the different assumptions of growth attributable to technical change and attributable to climate change (column C). We then derive the proportional growth factors under these different scenarios (column B).

Table B.1
Analysis of Various Growth Rates Attributable to Technical Change (Output Per Acre) and Attributable to Climate Change and Their Impact on the Value of Total Additional Output in 2030 and the Derived Growth in California International Exports

<table>
<thead>
<tr>
<th>Output/acre growth, by 2030</th>
<th>Climate change (^2)</th>
<th>Crop shift</th>
<th>Land loss</th>
<th>Net change</th>
<th>Domestic demand growth (^3)</th>
<th>Internatl. net exports (^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case (^5)</td>
<td>+43%</td>
<td>+15%</td>
<td>+10%</td>
<td>-10%</td>
<td>+58%</td>
<td>+46.5%</td>
</tr>
<tr>
<td>Output/acre growth, 1.4%/year</td>
<td>+51%</td>
<td>+15%</td>
<td>+10%</td>
<td>-10%</td>
<td>+66%</td>
<td>+46.5%</td>
</tr>
<tr>
<td>Output/acre growth, 1.0%/year</td>
<td>+34%</td>
<td>+15%</td>
<td>+10%</td>
<td>-10%</td>
<td>+49%</td>
<td>+46.5%</td>
</tr>
<tr>
<td>Output/acre growth, 0.9%/year (^6)</td>
<td>+31.5</td>
<td>+15%</td>
<td>+10%</td>
<td>-10%</td>
<td>+46.5%</td>
<td>+46.5%</td>
</tr>
<tr>
<td>Climate change growth, high</td>
<td>+43%</td>
<td>+20%</td>
<td>+10%</td>
<td>-10%</td>
<td>+63%</td>
<td>+46.5%</td>
</tr>
<tr>
<td>Climate change growth, low</td>
<td>+43%</td>
<td>+10%</td>
<td>+10%</td>
<td>-10%</td>
<td>+53%</td>
<td>+46.5%</td>
</tr>
<tr>
<td>Climate change growth, min 3.5% (^6)</td>
<td>+43%</td>
<td>+3.5%</td>
<td>+10%</td>
<td>-10%</td>
<td>+46.5%</td>
<td>+46.5%</td>
</tr>
</tbody>
</table>

\(^1\) The column presents the compounded growth in output per acre assuming various growth rates. \(^2\) The column presents the various growth rates attributed to climate change. \(^3\) Domestic demand growth includes the additional demand from growth in California population and population in the rest of the United States (based on Table 5). \(^4\) This column contains the share of food produced in California that can be used for international exports under the various growth rates in output/acre. \(^5\) Base case reported in tables 4, 5 and 5a. \(^6\) The minimum growth rate attributable to output/acre (row 4) and attributable to climate change (bottom row) to equal the demand growth in California and the rest of the United States (but not leave any food products for international exports).
### Table B.1b
Derived Growth in Value of California International Exports

<table>
<thead>
<tr>
<th>Year 2001 % of California production¹</th>
<th>Derived proportional growth from 2001 to 2030</th>
<th>Growth in California food supplies available for international exports²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>(B=C/A)</td>
<td>(C)</td>
</tr>
<tr>
<td>Base case</td>
<td>9.6%</td>
<td>1.20</td>
</tr>
<tr>
<td>High output/acre growth</td>
<td>9.6%</td>
<td>2.03</td>
</tr>
<tr>
<td>Low output/acre growth</td>
<td>9.6%</td>
<td>0.26</td>
</tr>
<tr>
<td>High climate change growth</td>
<td>9.6%</td>
<td>1.72</td>
</tr>
<tr>
<td>Low climate change growth</td>
<td>9.6%</td>
<td>0.68</td>
</tr>
</tbody>
</table>

¹ Based on table 1, last column.
² Based on table B.1.
Appendix C. Climate Change

Adams, Wu and Houston (2003) provide estimates on projected yield growth as a consequence of global climate change in a study prepared for the Electric Power Research Institute and the California Energy Commission. One step in their research was to develop crop yield response functions that estimate the effects of changes in temperature and precipitation on yields of major crops in California. They then apply these to climate change scenarios. The resulting yield estimates are presented for a range of climatic change scenarios and include assumptions concerning the effects of changes in CO₂ levels on crop yields. The information obtained for the three time periods modeled in the study are presented in tables C.1 through C.4 for the four production regions identified in the study:

Sacramento and the Delta regions, including Butte, Colusa, Contra Costa, Glenn, Sacramento, San Joaquin, Solano, Sutter, Tehema, Yolo and Yuba counties

San Joaquin and Desert Regions, including Fresno, Imperial, Kern, Kings, Madera, Merced, Riverside, Stanislaus and Tulare counties

North East and Mountain Regions: Calaveras, El Dorado, Lassen, Mariposa, Modoc, Nevada, Placer, Shasta, Siskiyou and Tuolumne counties.

Coast Regions, including Lake, Los Angeles, Monterey, Napa, Orange, San Benito, San Diego, San Luis Obispo, Santa Barbara and Sonoma counties.

These estimates provide the basis for our projections of the impacts of climate change on yields by 2030.
### Table C.1
Percent Change in Yields for the Sacramento and Delta Regions of California, by Uniform Scenario, with CO2 Fertilizer Effects

<table>
<thead>
<tr>
<th>Year forecasted</th>
<th>2100</th>
<th>2100</th>
<th>2100</th>
<th>2060</th>
<th>2020</th>
<th>2020</th>
<th>2020</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature change (C°)</td>
<td>3.00</td>
<td>3.00</td>
<td>5.00</td>
<td>1.80</td>
<td>0.60</td>
<td>1.50</td>
<td>5.00</td>
<td>1.50</td>
</tr>
<tr>
<td>Temperature change (F°)</td>
<td>5.40</td>
<td>5.40</td>
<td>9.00</td>
<td>3.24</td>
<td>1.08</td>
<td>2.70</td>
<td>9.00</td>
<td>2.70</td>
</tr>
<tr>
<td>Precipitation change %</td>
<td>0%</td>
<td>18%</td>
<td>0%</td>
<td>11%</td>
<td>4%</td>
<td>9%</td>
<td>9%</td>
<td>30%</td>
</tr>
<tr>
<td>Crop</td>
<td>Change in yield (% change)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn grain</td>
<td>14.6%</td>
<td>17.5%</td>
<td>27.5%</td>
<td>10.5%</td>
<td>5.1%</td>
<td>9.0%</td>
<td>33.0%</td>
<td>7.7%</td>
</tr>
<tr>
<td>Corn silage</td>
<td>2.8%</td>
<td>4.6%</td>
<td>0.4%</td>
<td>4.2%</td>
<td>3.5%</td>
<td>4.0%</td>
<td>4.7%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Barley</td>
<td>4.8%</td>
<td>2.8%</td>
<td>-4.3%</td>
<td>8.5%</td>
<td>13.6%</td>
<td>9.9%</td>
<td>-7.9%</td>
<td>10.7%</td>
</tr>
<tr>
<td>Sorghum</td>
<td>3.9%</td>
<td>3.0%</td>
<td>0.1%</td>
<td>4.7%</td>
<td>5.7%</td>
<td>5.0%</td>
<td>-1.5%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Dry beans</td>
<td>23.3%</td>
<td>47.1%</td>
<td>26.3%</td>
<td>32.3%</td>
<td>22.9%</td>
<td>29.1%</td>
<td>84.6%</td>
<td>21.4%</td>
</tr>
<tr>
<td>Oats</td>
<td>15.4%</td>
<td>13.8%</td>
<td>12.4%</td>
<td>15.0%</td>
<td>15.7%</td>
<td>15.2%</td>
<td>11.1%</td>
<td>16.2%</td>
</tr>
<tr>
<td>Rice</td>
<td>21.9%</td>
<td>20.9%</td>
<td>24.9%</td>
<td>19.0%</td>
<td>16.5%</td>
<td>18.4%</td>
<td>22.9%</td>
<td>18.8%</td>
</tr>
<tr>
<td>Sugar beets</td>
<td>28.1%</td>
<td>30.9%</td>
<td>36.7%</td>
<td>25.6%</td>
<td>21.6%</td>
<td>24.5%</td>
<td>42.5%</td>
<td>23.4%</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>16.9%</td>
<td>13.2%</td>
<td>20.2%</td>
<td>13.7%</td>
<td>14.9%</td>
<td>14.0%</td>
<td>14.2%</td>
<td>15.8%</td>
</tr>
<tr>
<td>Orange, Valencia</td>
<td>37.9%</td>
<td>30.0%</td>
<td>39.8%</td>
<td>33.8%</td>
<td>33.6%</td>
<td>34.2%</td>
<td>14.2%</td>
<td>35.4%</td>
</tr>
<tr>
<td>Hay, alfalfa</td>
<td>20.1%</td>
<td>20.6%</td>
<td>26.4%</td>
<td>16.3%</td>
<td>12.1%</td>
<td>15.2%</td>
<td>28.1%</td>
<td>15.1%</td>
</tr>
<tr>
<td>Grapes, table and raisin</td>
<td>7.5%</td>
<td>-10.0%</td>
<td>-16.7%</td>
<td>8.5%</td>
<td>20.8%</td>
<td>12.4%</td>
<td>-54.9%</td>
<td>19.1%</td>
</tr>
<tr>
<td>Grapes, wine</td>
<td>37.9%</td>
<td>35.6%</td>
<td>44.1%</td>
<td>31.8%</td>
<td>27.4%</td>
<td>30.8%</td>
<td>40.3%</td>
<td>32.0%</td>
</tr>
<tr>
<td>Tomatoes, fresh</td>
<td>15.7%</td>
<td>16.7%</td>
<td>-3.6%</td>
<td>22.4%</td>
<td>24.9%</td>
<td>23.3%</td>
<td>0.2%</td>
<td>23.3%</td>
</tr>
<tr>
<td>Tomatoes, process</td>
<td>29.4%</td>
<td>25.5%</td>
<td>32.2%</td>
<td>25.8%</td>
<td>25.5%</td>
<td>25.9%</td>
<td>23.0%</td>
<td>27.2%</td>
</tr>
<tr>
<td>Almonds</td>
<td>78.8%</td>
<td>79.8%</td>
<td>121.6%</td>
<td>56.2%</td>
<td>35.8%</td>
<td>50.8%</td>
<td>126.3%</td>
<td>51.0%</td>
</tr>
<tr>
<td>Walnuts, English</td>
<td>32.5%</td>
<td>26.8%</td>
<td>35.1%</td>
<td>26.8%</td>
<td>25.8%</td>
<td>26.7%</td>
<td>24.5%</td>
<td>29.3%</td>
</tr>
<tr>
<td>Prunes, dried</td>
<td>63.4%</td>
<td>65.9%</td>
<td>100.5%</td>
<td>46.7%</td>
<td>31.3%</td>
<td>42.5%</td>
<td>106.5%</td>
<td>41.6%</td>
</tr>
<tr>
<td>Olives</td>
<td>3.9%</td>
<td>3.2%</td>
<td>-22.8%</td>
<td>14.4%</td>
<td>22.2%</td>
<td>16.7%</td>
<td>-22.8%</td>
<td>17.3%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>-5.2%</td>
<td>-5.8%</td>
<td>-14.1%</td>
<td>-0.8%</td>
<td>3.8%</td>
<td>0.4%</td>
<td>-15.1%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

This region includes Butte, Colusa, Contra Costa, Glenn, Sacramento, San Joaquin, Solano, Sutter, Tehema, Yolo and Yuba counties. Source: Adams, Wu and Houston.
Table C.2
Percent Change in Yields for the S.J. Valley and Desert Regions of California, by Uniform Scenario, with CO₂ Fertilizer Effects

<table>
<thead>
<tr>
<th>Year forecasted</th>
<th>2100</th>
<th>2100</th>
<th>2100</th>
<th>2060</th>
<th>2020</th>
<th>2020</th>
<th>2020</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature change (C°)</td>
<td>3.00</td>
<td>3.00</td>
<td>5.00</td>
<td>1.80</td>
<td>0.60</td>
<td>1.50s</td>
<td>5.00</td>
<td>1.50</td>
</tr>
<tr>
<td>Temperature change (F°)</td>
<td>5.40</td>
<td>5.40</td>
<td>9.00</td>
<td>3.24</td>
<td>1.08</td>
<td>2.70</td>
<td>9.00</td>
<td>2.70</td>
</tr>
<tr>
<td>Precipitation change %</td>
<td>0%</td>
<td>18%</td>
<td>0%</td>
<td>11%</td>
<td>4%</td>
<td>9%</td>
<td>30%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop</th>
<th>Change in yield (% change)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grain</td>
<td>-3.3%</td>
</tr>
<tr>
<td>Corn silage</td>
<td>6.3%</td>
</tr>
<tr>
<td>Barley</td>
<td>2.1%</td>
</tr>
<tr>
<td>Sorghum</td>
<td>1.7%</td>
</tr>
<tr>
<td>Cotton, pima</td>
<td>9.9%</td>
</tr>
<tr>
<td>Copper</td>
<td>5.3%</td>
</tr>
<tr>
<td>Drybeans</td>
<td>10.9%</td>
</tr>
<tr>
<td>Oats</td>
<td>-17.5%</td>
</tr>
<tr>
<td>Rice</td>
<td>7.4%</td>
</tr>
<tr>
<td>Sugarbeets</td>
<td>12.5%</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>12.7%</td>
</tr>
<tr>
<td>Durum wheat</td>
<td>18.9%</td>
</tr>
<tr>
<td>Orange, Valencia</td>
<td>17.5%</td>
</tr>
<tr>
<td>Hay Alfalfa</td>
<td>18.7%</td>
</tr>
<tr>
<td>Grapes, table and raisin</td>
<td>-13.2%</td>
</tr>
<tr>
<td>Grapes, wine</td>
<td>41.5%</td>
</tr>
<tr>
<td>Tomatoes, fresh</td>
<td>-12.4%</td>
</tr>
<tr>
<td>Tomatoes, process</td>
<td>27.1%</td>
</tr>
<tr>
<td>Almonds</td>
<td>78.8%</td>
</tr>
<tr>
<td>Walnuts, English</td>
<td>32.6%</td>
</tr>
<tr>
<td>Prunes, dried</td>
<td>68.4%</td>
</tr>
<tr>
<td>Olives</td>
<td>-15.0%</td>
</tr>
<tr>
<td>Avocados</td>
<td>26.0%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>-8.9%</td>
</tr>
</tbody>
</table>

This region includes Fresno, Imperial, Kern, Kings, Madera, Merced, Riverside, Stanislaus and Tulare counties.
Source: Adams, Wu and Houston.
### Table C.3
Percent Change in Yields for the North-East and Mountain Regions of California, by Uniform Scenario, with CO₂ Fertilizer Effects

<table>
<thead>
<tr>
<th>Year forecasted</th>
<th>2100</th>
<th>2100</th>
<th>2100</th>
<th>2060</th>
<th>2020</th>
<th>2020</th>
<th>2020</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature change (°C)</td>
<td>3.00</td>
<td>3.00</td>
<td>5.00</td>
<td>1.80</td>
<td>0.60</td>
<td>1.50</td>
<td>5.00</td>
<td>1.50</td>
</tr>
<tr>
<td>Temperature change (°F)</td>
<td>5.40</td>
<td>5.40</td>
<td>9.00</td>
<td>3.24</td>
<td>1.08</td>
<td>2.70</td>
<td>9.00</td>
<td>2.70</td>
</tr>
<tr>
<td>Precipitation change %</td>
<td>0%</td>
<td>18%</td>
<td>0%</td>
<td>11%</td>
<td>4%</td>
<td>9%</td>
<td>30%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop</th>
<th>Change in Yield (% change)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grain</td>
<td>-3.3% -0.3% -16.4% 2.2% 2.0% 2.4% -10.4% 1.1%</td>
</tr>
<tr>
<td>Corn silage</td>
<td>9.2% 9.2% 13.3% 6.7% 4.3% 6.1% 13.3% 6.1%</td>
</tr>
<tr>
<td>Barley</td>
<td>33.4% 30.9% 58.1% 22.1% 17.1% 20.5% 54.0% 21.8%</td>
</tr>
<tr>
<td>Oats</td>
<td>8.6% 7.9% 12.1% 7.5% 8.0% 7.5% 10.7% 7.8%</td>
</tr>
<tr>
<td>Rice</td>
<td>-0.7% -3.7% 15.8% -10.7% -16.5% -12.2% 10.7% -10.8%</td>
</tr>
<tr>
<td>Sugarbeets</td>
<td>19.7% 26.0% 19.8% 23.5% 21.3% 22.9% 30.7% 19.7%</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>3.3% 3.6% -0.2% 6.0% 8.6% 6.6% 0.4% 6.4%</td>
</tr>
<tr>
<td>Hay, alfalfa</td>
<td>24.4% 24.8% 33.8% 18.7% 12.6% 17.1% 35.4% 17.1%</td>
</tr>
<tr>
<td>Grapes, wine</td>
<td>86.8% 80.7% 107.4% 69.4% 57.1% 66.5% 97.3% 69.6%</td>
</tr>
<tr>
<td>Walnuts, English</td>
<td>68.1% 52.0% 83.3% 48.1% 42.5% 47.0% 54.6% 54.7%</td>
</tr>
<tr>
<td>Olives</td>
<td>23.0% 23.0% 9.9% 26.7% 27.8% 27.3% 10.8% 27.5%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>-4.7% -5.3% -11.0% -1.8% 1.5% -0.9% -12.0% -0.6%</td>
</tr>
</tbody>
</table>

This region includes Calaveras, El Dorado, Lassen, Mariposa, Modoc, Nevada, Placer, Shasta, Siskiyou and Tuolumne counties.

Source: Adams, Wu and Houston.
### Table C.4
Percent Change in Yields for the Coast Region of California, by Uniform Scenario, with CO2 Fertilizer Effects

<table>
<thead>
<tr>
<th>Year forecasted</th>
<th>2100</th>
<th>2100</th>
<th>2100</th>
<th>2060</th>
<th>2020</th>
<th>2020</th>
<th>2020</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature change (C°)</td>
<td>3.00</td>
<td>3.00</td>
<td>5.00</td>
<td>1.80</td>
<td>0.60</td>
<td>1.50</td>
<td>5.00</td>
<td>1.50</td>
</tr>
<tr>
<td>Temperature change (F°)</td>
<td>5.40</td>
<td>5.40</td>
<td>9.00</td>
<td>3.24</td>
<td>1.08</td>
<td>2.70</td>
<td>9.00</td>
<td>2.70</td>
</tr>
<tr>
<td>Precipitation change %</td>
<td>0%</td>
<td>18%</td>
<td>0%</td>
<td>11%</td>
<td>4%</td>
<td>9%</td>
<td>30%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop</th>
<th>Change in Yield (% change)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grain</td>
<td>42.1% 35.0% 57.0% 31.1% 25.6% 30.0% 37.3% 31.7%</td>
</tr>
<tr>
<td>Corn silage</td>
<td>-31.3% -34.6% -45.5% -27.8% -24.4% -26.6% -53.7% -25.5%</td>
</tr>
<tr>
<td>Barley</td>
<td>15.1% 15.4% 18.7% 14.5% 14.7% 14.4% 19.6% 14.4%</td>
</tr>
<tr>
<td>Drybeans</td>
<td>34.7% -3.3% 49.1% 11.1% 20.7% 14.5% -39.9% 27.7%</td>
</tr>
<tr>
<td>Oats</td>
<td>37.8% 33.1% 43.6% 34.6% 36.8% 35.1% 32.4% 36.7%</td>
</tr>
<tr>
<td>Sugarbeets</td>
<td>48.5% 66.6% 76.8% 46.3% 28.5% 41.3% 106.5% 32.1%</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>-1.6% 2.0% 9.3% -2.1% -3.7% -2.8% 14.6% -4.7%</td>
</tr>
<tr>
<td>Orange, Valencia</td>
<td>13.1% 10.5% 4.5% 17.6% 22.8% 19.1% -5.8% 19.1%</td>
</tr>
<tr>
<td>Hay, alfalfa</td>
<td>26.2% 27.0% 30.8% 23.7% 20.4% 22.9% 32.9% 22.6%</td>
</tr>
<tr>
<td>Grapes, wine</td>
<td>90.2% 84.4% 85.0% 87.7% 89.5% 88.4% 75.4% 91.4%</td>
</tr>
<tr>
<td>Tomatoes, fresh</td>
<td>32.7% 34.1% 31.1% 30.2% 23.9% 28.9% 35.0% 28.5%</td>
</tr>
<tr>
<td>Tomatoes-process</td>
<td>21.5% 17.6% 24.8% 17.8% 17.1% 17.7% 15.5% 19.0%</td>
</tr>
<tr>
<td>Almonds</td>
<td>78.8% 79.8% 121.6% 56.2% 35.8% 50.8% 126.3% 51.0%</td>
</tr>
<tr>
<td>Walnuts, English</td>
<td>79.9% 68.9% 75.8% 74.3% 77.7% 75.5% 55.3% 80.5%</td>
</tr>
<tr>
<td>Prunes, dried</td>
<td>83.3% 86.5% 113.5% 72.0% 62.0% 69.0% 121.1% 67.9%</td>
</tr>
<tr>
<td>Avocados</td>
<td>29.0% 13.4% 30.7% 20.8% 23.9% 22.2% -9.3% 26.9%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>-16.1% -16.7% -22.9% -12.8% -9.2% -11.8% -24.1% -11.5%</td>
</tr>
</tbody>
</table>

This region includes Lake, Los Angeles, Monterey, Napa, Orange, San Benito, San Diego, San Luis Obispo, Santa Barbara and Sonoma counties.

Source: Adams, Wu and Houston.
Future Scenarios Presented in Water Plan Update 2005
Future Scenarios Presented in Water Plan Update 2005

Introduction

The concept of scenario planning is like a decision tree analysis that outlines different actions or responses based on different plausible futures. Some actions would be common and implemented regardless of the scenario; other actions will be taken in response to specific conditions. Scenarios are neither positive nor negative.

Multiple future scenarios provide decision-makers, water managers, and planners much more information about what they might expect in the future and how different management actions might perform across a range of possible futures. The scenarios are created by varying important assumptions about water and other resource conditions in order to highlight important categories of uncertainties. This multiple scenario approach is a milestone departure from previous water plan updates, which had based planning assumptions on a single future condition.

The primary reason to use multiple scenarios is that different assumptions about the future can significantly affect the nature and outcome of various mixes of management strategies. Some management strategies may be effective and economical regardless of the future scenario. Other strategies may only be suited if specific conditions develop in the future.

Peter Schwartz, a pioneer in the field of scenario planning, explains:

In a scenario process, managers invent and then consider, in depth, several varied stories of equally plausible futures. The stories are carefully researched, full of relevant detail, oriented toward real-life decisions, and designed (one hopes) to bring forward surprises and unexpected leaps of understanding. Together, the scenarios comprise a tool for ordering one’s perceptions. The point is not to “pick one preferred future,” and hope for it to come to pass. Nor is the point to find the most probably future and adapt to it or “bet the company” on it. Rather, the point is to make strategic decisions that will be sound for all plausible futures. No matter what future takes place, you are much more likely to be ready for it—and influential in it—if you have thought seriously about scenarios.1

Water Plan Baseline Scenarios for 2030

For Water Plan Update 2005, DWR and the Advisory Committee developed three scenarios of plausible events that could shape future water use by 2030. The scenarios describe the plausible conditions that could happen. The scenarios concentrate on statewide implications of regional shifts.

The introduction of scenarios is the biggest difference between the approach used in previous updates and the new approach, which is to compare performance among possible management responses to expected change. Scenarios represent the baseline conditions that we could reasonably expect to face in the year 2030, based on what we know to be true today. Any attempt to forecast or predict what the water management system will be like 25 years from now is highly uncertain.

Recognizing how uncertain these attempts to describe the future are, DWR has decided to present multiple scenarios that are plausible, but might cause water managers to respond very differently. These scenarios are not meant to forecast an actual outcome, but rather provide clear and systematic basis for comparing possible management responses and, in particular, highlight those responses that perform best when compared across a wide array of baseline conditions that could occur in the future.

Describing Expected Changes with Three Preliminary Scenarios of Baseline Conditions for 2030

While DWR has decided to use multiple future scenarios in the quantitative work for The next Water Plan Update, it has not yet developed the analytic tools to do so. To demonstrate how scenarios can be used to better understand the implications of future conditions on water management decisions, however, the Water Plan Update 2005 presents three baseline scenarios. The narrative descriptions of these scenarios were developed by water plan staff and the Advisory Committee. These scenarios are referred to as baseline because they represent changes that are reasonably likely to occur without additional management intervention beyond those currently planned.

Developing quantitative estimates of water demands and supplies for multiple future scenarios and management responses requires using available data and assumed relationships. The following are the three plausible scenarios; however, DWR and stakeholders may develop other scenarios as work on the next Water Plan Update progresses:

- **Scenario 1—Current Trends**: Recent trends continue for the following: population growth and development patterns, agricultural and industrial production, environmental water dedication, and naturally occurring conservation (like plumbing code changes, natural replacement, actions water users implement on their own, etc.).
- **Scenario 2—Less Resource Intensive**: Recent trends for population growth, higher agricultural and industrial production, more environmental water dedication, and higher naturally occurring
conservation than Current Trends (but less than full implementation of all cost-effective conservation measures currently available).

- Scenario 3—More Resource Intensive: Higher population growth rate, higher agricultural and industrial production, no additional environmental water dedication (year 2000 level), and lower naturally occurring conservation than Current Trends.

All three scenarios include assumptions for two kinds of water use efficiency actions: (1) those that water users take on their own (called naturally occurring conservation) and (2) those encouraged by water agency programs, policies, and requirements. Only naturally occurring conservation was varied among the scenarios; and all scenarios include the same continued implementation of cost-effective actions by water agencies.

**Key Factors**

DWR and stakeholders considered numerous factors that could vary in the future and developed three preliminary narrative future scenarios that can be used to begin the analysis for *The next Water Plan Update*. The following table (“Factors affecting regional and statewide water demands and supplies”) shows factors that may vary across scenarios. Each factor must be quantified. The availability and resolution of data varies widely. While key factors have been identified, much work remains before reaching agreement on the relationships between the factors and the methods that will be used to quantify them.
Factors affecting regional and statewide water demands and supplies

<table>
<thead>
<tr>
<th>Table 4-1</th>
<th>Scenario factors affecting regional and statewide water demands and supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FACTOR</strong></td>
<td><strong>SCENARIO 1 CURRENT TRENDS</strong></td>
</tr>
<tr>
<td>Total Population</td>
<td>DOF</td>
</tr>
<tr>
<td>Population Density</td>
<td>DOF</td>
</tr>
<tr>
<td>Population Distribution</td>
<td>DOF</td>
</tr>
<tr>
<td>Commercial Activity</td>
<td>Current Trend</td>
</tr>
<tr>
<td>Commercial Activity Mix</td>
<td>Current Trend</td>
</tr>
<tr>
<td>Total Industrial Activity</td>
<td>Current Trend</td>
</tr>
<tr>
<td>Industrial Activity Mix</td>
<td>Current Trend</td>
</tr>
<tr>
<td>Irrigated Crop Area (Includes Irrigated Land Area and Multi-cropped area)</td>
<td>Current Trend</td>
</tr>
<tr>
<td>Crop Unit Water Use</td>
<td>Current Trend</td>
</tr>
<tr>
<td>Environmental Water-Flow Based</td>
<td>Current Trend</td>
</tr>
<tr>
<td>Environmental Water-Land Based</td>
<td>Current Trend</td>
</tr>
<tr>
<td>Naturally Occurring Conservation*</td>
<td>Current Trend</td>
</tr>
<tr>
<td>Urban Water Use Efficiency</td>
<td>Per Capita Income</td>
</tr>
<tr>
<td>Ag Water Use Efficiency</td>
<td>Ratio of Seasonal to Permanent Crop Mix</td>
</tr>
<tr>
<td>Per Capita Income</td>
<td>Hydrology</td>
</tr>
<tr>
<td>Irrigated Crop Area</td>
<td>Climate Change</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Colorado River Supply</td>
</tr>
<tr>
<td>Climate Change</td>
<td>Existing Inter-Regional Import Projects</td>
</tr>
<tr>
<td>Colorado River Supply</td>
<td>Flood Management</td>
</tr>
<tr>
<td>Existing Inter-Regional Import Projects</td>
<td>Energy Costs</td>
</tr>
<tr>
<td>Flood Management</td>
<td>Ambient Water Quality</td>
</tr>
<tr>
<td>Energy Costs</td>
<td>Drinking Water Standards</td>
</tr>
<tr>
<td>Drinking Water Standards</td>
<td>Ag Discharge Requirements</td>
</tr>
<tr>
<td>Ag Discharge Requirements</td>
<td>Urban Runoff Mgmt.</td>
</tr>
<tr>
<td>Urban Runoff Mgmt.</td>
<td>Recreation</td>
</tr>
<tr>
<td>Recreation</td>
<td>Desalting</td>
</tr>
<tr>
<td>Desalting</td>
<td>Recycled Water</td>
</tr>
<tr>
<td>Recycled Water</td>
<td>Water Transfers Within Regions</td>
</tr>
<tr>
<td>Water Transfers Within Regions</td>
<td>Water Transfers Between Regions</td>
</tr>
<tr>
<td>Water Transfers Between Regions</td>
<td>Integrated Ground &amp; Surface Water Mgmt.</td>
</tr>
<tr>
<td>Integrated Ground &amp; Surface Water Mgmt.</td>
<td>Groundwater Storage</td>
</tr>
<tr>
<td>Groundwater Storage</td>
<td>Surface Water Storage</td>
</tr>
<tr>
<td>Surface Water Storage</td>
<td>Conveyance Facilities</td>
</tr>
<tr>
<td>Conveyance Facilities</td>
<td>Rate Structure</td>
</tr>
</tbody>
</table>

(1) Factors should be considered as an initial list that will be modified, as needed, as analyses proceed for next Water Plan Update.
(2) Naturally Occurring Conservation is the amount of background conservation (changes in plumbing code, etc.) occurring independently from the BMP and EWMP programs.
While all the factors in the table are needed to define the strategies, DWR has begun its analysis by varying only the factors in the upper portion. The factors defined below are primarily related to land and water use patterns over which the water community has little control. DWR may need to vary other factors in the table to gain insight into specific operations.

**Key Factors Affecting Water Demand:**

**Total Population**  
The statewide total population projection regardless of geographical distribution.

**Population Density**  
The average number of people per square mile for a planning area.

**Per Capita Income**  
The average annual income from all sources per person for a planning area.

**Total Commercial Activity**  
Total commercial activity refers to all activities in the service-producing sectors, which include farm services, transportation, public utilities, trade, finance, insurance, real estate, services, and government. This factor is a driver of (and indicator for) commercial water use (business offices) as well as institutional water use (government offices, schools, etc.).

**Commercial Activity Mix**  
The mix of high and low water using commercial activity. Note that Commercial Activity is broken into two factors: Total Activity and Activity Mix. The latter factor allows designation of the type of commercial activity that is occurring.

**Total Industrial Activity**  
Total industrial activity refers to all activities in good-producing sectors, which include farm production, mining, construction, and manufacturing. This factor is a driver of (and indicator for) industrial water use. Note that Industrial Activity is broken into two factors: Total Industrial Activity and Industrial Activity Mix. The latter factor allows designation of the type of industry that is occurring. This is necessary to account for the large variation in water demands by industry type.

**Industrial Activity Mix**  
The mix of high and low water using industrial activity. Note that Industrial Activity is broken into two factors: Total industrial Activity and Industrial Activity Mix. The latter factor allows designation of the type of industry that is occurring. This is necessary to account for large variation in water demands by industry type.

**Irrigated Land Area**  
The land area under irrigation in a study area.

**Crop Acreage**  
The number of irrigated crop acres (by crop category) planted in a study area during a given year; this number includes multiple cropping.
Crop Unit Water Use
Changes in the volume of water used per acre of cropped area due to changes in crop type. This can be a function of evapotranspiration rates and cultural practices, but NOT use efficiency. Agricultural water use efficiency is captured under its own distinct factor.

Environmental Water – Flow Based
The amount of water dedicated to in stream uses and aquatic habitat. Flow based is estimated by (a) Delta outflow, (b) in stream flow requirements, (c) Wild and Scenic River flows (d) Environmental Water Account asset allocations, (e) Anadromous Fish Restoration Program flows, and (f) Ecosystem Restoration Program flow targets.

Environmental Water – Land Based
The amount of water used by managed wetlands and native vegetation. The amount should be estimated by the amount of water used by managed wetlands and native vegetation including riparian water use, however, native vegetation water use is not quantifiable at this time.

Naturally Occurring Conservation:
The amount of background conservation occurring independent of the BMP and EWMP programs.

Description of Preliminary Scenarios
This section describes key narrative assumptions made for each “no action” scenario by category of possible change.

Scenario 1: Current Trends

Population and Land Use
- Population in 2030 is what the California Department of Finance has projected – 48.1 million people.\(^2\)
- Increasing population pressure in the valley and on the California coast. Most people are moving to cities with large populations and high percentages of growth in Fresno, Stockton, Modesto, Bakersfield and San Diego.
- Expanding metropolitan areas continue to affect the residents’ daily lives and agriculture.
- The cost of land in Southern California is growing—with shrinking availability.
- **Placeholder: add something on per capita income trends.**

Commercial and Industrial
- Industry has become more efficient in water use—driven to reduce costs in the face of competition. When possible, industries like concrete have moved to dry processing to eliminate water necessary to create its product—reducing costs.
- Businesses have been reducing water use over time because it is cost effective, primarily by replacing old or broken-down equipment with high efficiency machines.

Agriculture
- Irrigated agricultural land will be less than it is currently. Irrigated crop acreage, which includes multi-cropping, will also be less than current levels, but will be less of a change than the land acreage due to increases in multicropping.
- Farmers are increasingly using sprinklers and drip irrigation, moving away from flooding and furrows. Farmers are able to turn irrigation on and off at will and decide exactly where to irrigate. Improved water management is modestly increasing water efficiency over 2000 levels. Irrigation techniques improve the uniform distribution of water to all plants, which is also contributing to an increase in plant size. Farmers produce more “crop per drop” through a variety of means, including changes in irrigation methods away from inefficient approaches, though more improvement is possible.
- A significant amount of the reduction in irrigated agricultural land is land with high quality soils. Any new land coming into production would be of poorer quality soils, decreasing some efficiency gains in applied water and yield per acre for those soils.
- Concerns about impacts to the local area from loss of farmland due to urbanization will continue to be addressed by local governments.

Environment
- Environmental flows would reach half way to levels needed to meet the objectives of CALFED’s Ecosystem Restoration Program and the objectives in the Anadromous Fisheries Restoration Program. Water dedicated to wetlands would reach half way to the “Level 4” supplemental water supplies for National Wildlife Refuges cited in CVPIA Sections 3405 and 3406(b).
- Some increase in the extent of managed wetlands designed to use in cleansing wastewater due to projects which use floodplains/wetlands for high flow management and ecosystem restoration programs.
- In some areas, continued loss of functioning floodplains due to the direct encroachment of urban development (flash floods and fast runoff).
- In urban areas, where new development has ended, continued regional and local efforts to restore functioning channels and floodplains.
- Environmental restoration projects do not fully offset ongoing losses of habitat (with species effects) and other watershed impacts.

Groundwater
- Increase in groundwater remediation and aquifer quality protection.

Efficiency
- Urban Best Management Practices (BMPs) are commonplace in most water agencies, including residential indoor and outdoor water use surveys and improvements; commercial, industrial, and institutional water use audits and retrofits, landscape irrigation audits and upgrades; district water system leak detection and repair programs; metering, commercial washing machine rebate programs, conservation pricing, waste water reduction ordinances, and public information and education programs.
- Urban landscape irrigation has decreased, where irrigation does occur, fewer chemicals are applied.
Existing efficiency standards affecting washing machines, toilets, spray valves in restaurants continue to be implemented.

**Water Quality**
- Water quality best management practices are limited to local affordability; limited public funding assistance is available.
- Current quality impairments continue in many waterways, particularly those which are not directly linked as urban drinking water sources.
- Urban stormwater runoff regulations are implemented, and point source controls continue to be implemented.
- Runoff from irrigated lands and lands used for grazing and timber harvest, nonpoint sources of water pollution, has moderately reduced.
- Some decrease in flexibility to meet Delta water quality standards, due to reduced surplus inflow and greater reuse of water upstream. Standards are assumed to be met.
- Substantial improvement in the effectiveness and affordability of water filtration technologies.

**Water Demand**
- Placeholder: Add in estimates for consumptive and applied water use for this scenario.

**Considerations**
- Placeholder: CALFED ROD assumptions
- Funding for agricultural and urban water use efficiency programs.
- Implementation of agricultural and urban efficiency measures is part of overall management strategy, not just a response to drought conditions.
- Continued resistance by some water agencies to implement agricultural and urban water use efficiency best management practices.
- Urban sprawl has consumed valuable farmland, open space and other natural resources and contributed to water pollution, extinction of species, and increased competition for limited water resources.
- Construction of vast amount of impervious surfaces, such as roads and rooftops lead to degradation of water quality by increasing surface runoff, altering regular stream flow and watershed hydrology, reducing groundwater recharge, and increasing stream sedimentation.
- Sprawl in metropolitan areas, and negative economic impacts in some areas (where known) have environmental justice implications.
- Assumptions about the management of drainage impaired lands will affect irrigated agriculture and have implications for water supply and water quality.

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3 Source: Resource management strategy narratives in Volume 2.
Scenario 2: Less Resource Intensive

Population and Land Use
- Population in 2030 is what the California Department of Finance has projected – 48.1 million people.\(^4\)
- Citizens live in mixed use developments with native vegetation requiring little or no irrigation. An increase in population density means infill in existing urban areas and less new urban land being developed. This compact development has reduced the need for impervious surfaces benefiting open space, reduced runoff and other related issues.
- The cost of land in Southern California is growing—with shrinking availability.
- Placeholder: add something on per capita income trends.

Commercial and Industrial
- The industrial, commercial and agricultural sectors are strong, balanced with high environmental protection.
- Urban areas have a high degree of commercial and industrial productivity.
- California is a global leader in all types of recycling technology.
- California has emerged as a leading industrial producer of environmental products and continued as a force in producing hardware for the technology industry.
- Industry has shifted from water-intensive processing to dry product assembly, reducing water use. Businesses have dramatically reduced demand. They have received incentives accelerating the move to machines with high efficiency water use to accomplish standard tasks.

Agriculture
- Statewide irrigated crop acreage will remain at year 2000 levels.
- Even with increasing urban densities, there will still be urbanization of agricultural land. Any land acreage removed from agricultural must be replaced by a combination of new land coming into production or an increase in multi-cropping, to keep the crop acreage at the current level.
- A viable agricultural sector has sustained export levels and food production in keeping with market forces and trends.
- The social contract continues to keep food and fiber prices low.
- A healthy, efficient agricultural sector has no new irrigated acres, but is able to produce more per acre and decrease applied water per irrigated crop acre.
- Farmers use sprinklers and drip irrigation on nearly all appropriate crops and lands. Flooding and furrow irrigation are applied only where more efficient methods cannot be used. Farmers turn irrigation on and off at will and decide exactly where to irrigate based on accurate information on soil moisture and climate conditions. Improved water management is increasing water efficiency. Irrigation techniques improve the uniform distribution of water to all plants, which is also contributing to yields.

Environment

Instream flows are sufficient to meet the objectives of CALFED’s Ecosystem Restoration Program and the Anadromous Fisheries Restoration Program.

- Environmental health regulations are fully enforced, especially for air and water quality.
- Projects are designed to achieve multiple benefits integrating ecosystem restoration with water supply reliability.
- Water dedicated to wetlands would reach “level 4” supplemental water supplies for National Wildlife Refuges cited in the CVPIA sections 3405 and 3406(b).
- River floodplain protection and restoration is undertaken for high flow management, habitat benefits, groundwater recharge, and public recreation (where appropriate).
- New developments and infrastructure (such as roads) are designed to minimize impacts to the natural drainage patterns and water quality of watersheds and increase groundwater recharge using urban water retention measures.
- Management actions are oriented toward the sustainability, restoration and improvement of the natural infrastructure.
- Californians recognize the link between the environment and their economic health and personal well being. Wetlands and native vegetation flourish through high environmental protection. Water dedicated to in stream use and enhancing aquatic life is finally yielding increased populations. The sense of the State and its policy is to sustain a high degree of environmental protection.

**Groundwater**
- There is increased utilization of existing groundwater aquifers to meet water demand and for water storage due to local cooperative watershed and integrated resource plans.
- Groundwater basins have been remediated and aquifer quality protection is in place.

**Economics and Water Pricing**
- Water has a high degree of economic optimization (e.g. $/drop) relative to existing economic activity types and water use efficiencies.
- Users are accustomed to paying more for water, especially in response to high levels of demand.
- The cost of investing in water use efficiency provides a return on investment.

**Transfers and Conveyance**
- Infrastructure is built to permit local and regional water transfers in order to balance water supplies (but not large inter-regional transfers, especially those that must pump through the Delta).

**Public Trust**
- Water managers recognize public trust responsibilities to protect waters of the state for environmental, recreational, and aesthetic values.

**Efficiency**
- Naturally occurring conservation (NOC) trend is higher in the agricultural and urban sectors than under Scenario 1. Business and agriculture have recognized the benefits of conservation and implemented efficiency measures that go far beyond best management practices in place in 2000.
Many houses are dual plumbed, enabling residents to use recycled water for appropriate uses. Municipal and agricultural best management practices become comprehensive, encouraging more water use efficiency improvements and practices to be developed. Native vegetation and other innovative landscaping techniques have greatly reduced residential demand for landscape irrigation.

**Water Quality**
- Water quality best management practices have been fully implemented.
- Implementation of urban stormwater runoff regulations and point source controls have exceeded anticipated levels.
- Runoff from irrigated lands and lands used for grazing and timber harvest, nonpoint sources of water pollution, has significantly reduced.
- Water quality in currently impaired lakes and rivers is substantially improved and clean waters are protected from degradation.

**Water Demand**
- Placeholder: Add in estimates for consumptive and applied water use for this scenario.

**Considerations**
- Placeholder: CALFED ROD assumptions
- Cost of implementation is a factor.
- Impact of climate change on hydrologies.
- Funding for agricultural and urban water use efficiency programs.
- Implementation of efficiency measures is part of overall management strategy, not just a response to drought conditions.
- Continued resistance by some water agencies to implement urban water use efficiency best management practices.
- Compact, mixed use development reduces water demand (landscaping) and minimizes pollution of surface and groundwater. Impacts to habitat, watershed functions, and groundwater recharge areas are reduced.
Scenario 3: More Resource Intensive

Population and Land Use
- Population in 2030 is 52.3 million people, which is higher than the California Department of Finance’s projection of about 48.1 million.\(^5\)
- The population is dispersed regionally. Expanding urban areas are commonplace.
- Build-out for many cities and towns in Northern California and coastal regions has not been reached. More people live in the inland areas of the Central Valley and in the southern regions of California. Fresno, Stockton, Modesto, Bakersfield and San Diego have large populations and have experienced high percentages of growth.
- The population is more spread out resulting in more outdoor residential water use (e.g. larger residential lot size).
- The Central Valley is experiencing air and water quality problems due to the stress of the high population.
- People tend to drive individually long distances to the work place.
- Placeholder: add something on per capita income trends.

Commercial and Industrial
- The industrial, commercial and agricultural sectors are strong, balanced with existing environmental protection.
- Difficulty attracting clean, efficient industries has an impact on the state’s attractiveness.
- California has become a global leader in recycling technology.
- California has emerged as a leading industrial producer of environmental products and continued as a force in producing hardware for the technology industry. California’s leadership in high tech hardware places constraints on its water resources since this industry is a high water using industry that has not achieved advances in technology to limit its water use.
- Industry continues to rely on high water-using processes based on market conditions.

Agriculture
- Statewide irrigated crop acreage will remain at year 2000 levels.
- The healthy agricultural sector maintains past levels of food and fiber production. Low-density urban development expands onto prime farmland, but harvested acreage remains about the same due to increased multi-cropping and new lands coming into production.
- The annual volume of applied water per crop is high due to the changing nature of crops grown and the movement of agricultural production to lands with poor soil quality.
- There are no new long-term transfers of water from the agricultural sector to the cities.

Environment
- Instream flows are not meeting objectives of CALFED’s Ecosystem Restoration Program and Anadromous Fisheries Restoration Program, but remain at year 2000 levels.
- Water dedicated to wetlands remains at year 2000 levels, and the “Level4” supplemental water supplies for National Wildlife Refuges cited in CVPIA sections 3405 and 3406(b) are not achieved.

• Californians recognize the link between the environmental and their health and personal well being, but there is less water available to the environment.

**Groundwater**
• Although some groundwater basins have been remediated and recharge protection is in place, groundwater overdraft is prevalent in the state and land subsidence occurs.

**Economics and Water Pricing**
• Water is used with a low degree of economic optimization (e.g. $/drop) relative to the economic activity types and efficiencies.

**Efficiency**
• Naturally occurring conservation in the agricultural and commercial and industrial sectors is lower than the current trends.

**Quality**
• Water quality best management practices have been fully implemented but not extended.
• Implementation of urban stormwater runoff regulations (NPDES) and point source controls have reached but not exceeded anticipated levels.
• Runoff from irrigated lands and lands used for grazing and timber harvest, nonpoint sources of water pollution, has significantly reduced.
• Improvements in water quality in impaired lakes from existing regulations are becoming more difficult to achieve.

**Water Demand**
• Water planners and decision makers have to contend with high water use in every sector.
• Water use is less efficient than in Scenario 2.
• Placeholder: Add in estimates for consumptive and applied water use for this scenario.

**Considerations**
• Placeholder: CALFED ROD assumptions.
• Water quality has become a major challenge due to the increased demands and expanding urban areas.
• Water conveyance requires a great deal of infrastructure improvement due to the dispersed population.
• Expanding urban areas have consumed valuable farmland, open space and other natural resources and contributed to water pollution, extinction of species, and increased competition for limited water resources.
• Construction of vast amount of surfaces, such as roads and rooftops lead to degradation of water quality by increasing surface runoff, altering regular stream flow and watershed hydrology, reducing groundwater recharge, and increasing stream sedimentation.
• Urban water availability is constrained by high water use and limited transfers from agriculture.
• Water prices are much higher as scarcity increases.
Involving Stakeholders In Irrigation And Drainage District Decisions: Who, What, When, Where, Why, How

By Lisa Beutler, Center for Collaborative Policy, California State University, Sacramento
IN INVOLVING STAKEHOLDERS IN IRRIGATION AND DRAINAGE DISTRICT DECISIONS: WHO, WHAT, WHEN, WHERE, WHY, HOW

Lisa Beutler¹

U.S. Committee on Irrigation and Drainage, proceedings of the Third International Conference on Irrigation and Drainage, March 2005

ABSTRACT
Many believe the public and other stakeholders should be considered in developing governance structures. Early engagement with stakeholders can provide an irrigation and drainage district with insight into their concerns and priorities, and outline relevant sustainability issues. Engagement also allows a district to manage expectations and concerns as well as assess strategic issues, opportunities and threats. Districts may utilize a variety of methods to identify stakeholders, discern when and where collaborative work should occur, and define the types of things stakeholders should or should not assist with.

INTRODUCTION

“Business as usual, government as usual, and perhaps even protest as usual are not giving us the progress needed to achieve sustainable development. Let’s see if we can’t work together to find better paths forward” (Hohnen 2001)²

In recent years numerous organizations, from government agencies to for-profit business, have realized the importance of engaging stakeholders in situation assessment and governance. The international community and particularly the United Nations (UN) have similarly embraced multi-stakeholder processes "to address issues that need public debate and stakeholder involvement and contentious issues of political, economic and technological development."³

Multi-stakeholder processes (MSPs) are processes which aim to bring together all major stakeholders in a different form of communication, fact finding, and possibly decision-making, on a particular issue.”⁴

¹ Associate Director, Center for Collaborative Policy, Sacramento State University, 1303 J. St, Suite 250, Sacramento, CA 95814
³ Hemmati, Minu, Multi-Stakeholder Processes for Governance and Sustainability - Beyond Deadlock and Conflict, London, Earthscan 2001
⁴ Ibid
Stakeholder processes are often utilized when decision bodies acknowledge a need for systemic, sustainable, and inclusive approaches. Although complex stakeholder processes can require large amounts of financial and human resources, some argue that stakeholder based processes are also more efficient and effective because they result in faster, less contested implementation of the resulting policies or projects. Many agencies have found it difficult to implement decisions without first gaining stakeholder buy-in.

**WHO ARE STAKEHOLDERS?**

Stakeholders are individuals or groups who can affect or be affected by an organization’s activities. This may include communities concerned with environmental impacts, consumers who want product information, and employees or investors who wish to see a company prosper.

Stakeholders are also those with a stake in what happens as a result of any decision or action. In less generous terms, some who find stakeholders difficult to work with define them as “someone who can mess with your business.”

With such broad definitions decision makers and project managers will need to distinguish between influencers and stakeholders. Some individuals with a real stake in an enterprise may have no influence, e.g. a job applicant, while some influencers of an organization may have no stake, e.g. the media. In some cases stakeholders also have influence (for example Board Members). In general, stakeholders are the appropriate parties to engage in situations involving governance and decision making issues.

Stakeholder identification begins with and is directly tied to project scoping. Many of the tools used to define stakeholders parallel those used to define customers. For example, there are several defined governmental sector customers: ones who use or consume services, ones who regulate it (Judicial and Legislative), ones who authorize it (Executive Branch and Legislature), ones who manage public approval (Executive), and ones affected by the exercise of authority. Stakeholders may include representatives of affected environments or constituencies, such as formal advocacy groups, industry councils, and public interest groups.

In looking at particular issues it is useful to create a comprehensive map or outline of stakeholders needed to help clarify the desired policy outcomes. One approach includes expressing desired outcomes in terms of the impact on key stakeholder

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groups. From the initial stakeholder map, a more sophisticated analysis of interests and influence is needed to help assess whether or not to utilize some form of stakeholder group as part of decision-making.

CHARACTERISTICS OF STAKEHOLDER GROUPS

Wide use of stakeholder processes is relatively new and evolving. Methods are continually being adapted based on cultures and desired group products. Even so, while each stakeholder process contains unique features based on purpose and other factors, there are a number of common elements most collaborative efforts share. Table 1 outlines some of those elements.

Table 1. Sample Characteristics of Stakeholder Groups

<table>
<thead>
<tr>
<th>Features</th>
<th>Equitable representation of three or more stakeholder groups and their views</th>
<th>Democratic principles of transparency and participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods</td>
<td>Dependent on issues, objectives, participants, scope, time lines, etc. may include:</td>
<td></td>
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<td></td>
<td>Dialogues on policy</td>
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<td></td>
<td>Information sharing</td>
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<td></td>
<td>Consensus-building, decision-making</td>
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<td></td>
<td>Implementation of practical solutions</td>
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<tr>
<td>Outcomes</td>
<td>Strengthened networks among and between stakeholders to achieve better system outcomes</td>
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<td></td>
<td>Accountability of decision-makers to the public and to key stakeholders</td>
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<td>Sample Products</td>
<td>Policy statements</td>
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<td></td>
<td>Response to agency prepared proposals</td>
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<td></td>
<td>Strategic plans</td>
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<td></td>
<td>Program plans</td>
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<td></td>
<td>Litigation settlements and/or agreements reached via alternative dispute resolution</td>
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<td>Site specific plans and agreements</td>
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</tbody>
</table>

As an example of products, the Extractive Industries Review, an entity within the World Bank, utilizes a multi-stakeholder approach to develop future policy on extractive industries, including oil, gas and mining. The objectives of this group were to record the positions of the stakeholders, assess consensus and dissent in selected pivotal issues, and to document them for political decision-makers. Where consensus existed the process aimed at formulating recommendations for the implementation of specific policies.
SELECTING A STAKEHOLDER PROCESS

Various studies have assessed stakeholder engagement methods. A United States Environmental Protection Agency (EPA) review of agency public involvement found, “Some stakeholder involvement activities appear to be conducted because they are considered a good thing but it might not be clear how the activities contribute to actual Agency decisions. This can lead to frustration as participant expectations do not coincide with Agency actions.” EPA also found that because regulatory, non-regulatory, and voluntary program activities had become more extensive and interwoven, “there is not always an understanding of the type of stakeholder involvement that is most appropriate in a particular situation and the model selected might not produce the type of results that are needed.”

Indeed, agencies may involve stakeholders at many levels. One size or method does not fit all. The degree of engagement should be determined by the scope of the issue, needs of decision makers, interest of stakeholders and expertise of the stakeholders.

Management writer Paula Bloom, in her research on internal stakeholders, focuses on the issues of interest and expertise. Bloom recommends designing strategies that match stakeholder interest and expertise with specific outreach methods. Bloom prescribes the following:

- Low interest, low expertise — avoid involvement
- Low interest, high expertise — consult
- High interest, low expertise — consult. The goal of the agency may be to lower resistance among the stakeholders, but this will require great care, sensitivity, and skilled leadership.
- High interest, high expertise — involve as early as possible, and given as much freedom as possible to define the problem and set objectives either as a delegated approach or a collaborative approach.

The International Association for Public Participation (IAP2) has created a Public Participation Spectrum that defines stakeholder methods by degrees of involvement, increasing level of impact, goals of outreach, public expectations, and tools and methods. The model framework ranges from inform, consult, and involve, to collaborate and empower.

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8 http://iap2.org/practitionertools/index.shtml, IAP2 Headquarters, 11166 Huron St. Suite 27, Denver, CO 80234 USA, E-mail-iap2@iap2.org
Based on research of effective processes, EPA created a template of participation models by type of issue and degree of desired engagement. Table 2 illustrates the framework.

Table 2. US EPA Typology Of Stakeholder Involvement Techniques

<table>
<thead>
<tr>
<th>ROLE OF THE AGENCY</th>
<th>ROLE OF PARTICIPANTS</th>
<th>DEVELOP RECOMMENDATIONS</th>
<th>DEVELOP AGREEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECISION MAKER</td>
<td>Exchange Information</td>
<td>Advisory group or task force</td>
<td>Negotiated rule-making</td>
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<td></td>
<td></td>
<td>Workshops</td>
<td>Consensus permits</td>
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<td>Mediation</td>
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<td>Negotiation</td>
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<tr>
<td>PARTNER</td>
<td>Conferences</td>
<td>Task force</td>
<td>Partnering</td>
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<tr>
<td></td>
<td>Technical workshops</td>
<td>Workshops</td>
<td>Memorandum of Cooperation</td>
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<tr>
<td></td>
<td>Roundtables</td>
<td>Community visioning process</td>
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<td></td>
<td></td>
<td>Roundtables</td>
<td></td>
</tr>
<tr>
<td>CAPACITY BUILDER</td>
<td>Community Profiling</td>
<td>Community consensus group</td>
<td>Technical Assistance Grants</td>
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<tr>
<td></td>
<td>Interviews</td>
<td>Community visioning process</td>
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<td></td>
<td>Technical assistance grants</td>
<td>Technical assistance grants</td>
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</tbody>
</table>

Both the EPA model and IAP2 spectrum are useful in selecting potential public involvement methods. In addressing complex issues it is not uncommon for organizations to utilize several different participation methods. An organization embarking on a very large, complex project may use many methods. For example, the public engagement process may include numerous and ongoing information exchanges with the general public, a focused stakeholder negotiation over environmental documents, technical assistance grants to a community to create capacity for managing new requirements created by the project, workshops to better define specific issues and use of an on-going stakeholder advisory group.

If, after analysis, an agency determines collaboration is the right approach to resolve an issue or develop a proposed action, the Center for Collaborative Policy, Sacramento State University defines eleven specific conditions that should be assessed before moving into a formal collaborative process.

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9 EPA Stakeholder Involvement, Action Plan, December 1, 1998,
10 http://www.csus.edu/ccp/collaborative/sustain.htm, Center for Collaborative Policy, Sacramento State University, 1303 J Street :: Sacramento, CA 95814
1. **Clear Role and Purpose**: Participants understand their role, their responsibilities, and the purpose of the effort.

2. **Transparency of Decision-Making**: How decisions will be made is discussed and identified in the first stages of a stakeholder process. This does not mean that stakeholders, as contrasted with authorized governmental bodies, need to be the ultimate decision-makers. Rather, it means that stakeholders understand the decision-making ground rules before they invest their time in the process. Based on their evaluation on the decision-making rules, they can choose to participate or not participate. This transparency extends to how the ultimate decision will be made as well as to how decisions, including advisory decisions, will be made within the stakeholder group itself.

3. **Interest-Based Decision-Making**: If consensus-building or collaboration among historical adversaries is a goal of the stakeholder effort, then the decision-making structure needs to reflect this goal. This would mean that for the outcome of process to be considered collaborative, the major interest groupings as defined by the collaborative would need to be supportive of the decision or recommendation.

4. **Every Effort to Bring Affected Stakeholders into the Process**: At the beginning of any process, a conscious and serious effort is made to identify and recruit stakeholders whose interests are affected by the discussions. This requires a thorough stakeholder analysis process at the start up of a collaborative process or advisory board process. Inclusiveness enhances the legitimacy of the process.

5. **Stakeholders Represent Organized Constituencies**: When organizing stakeholder processes, as a general rule the participants should represent and be accountable to established organizations, or communities of interest rather than serving as individual citizens.

6. **Upfront Exploration of Interests**: During the initial stages of a process, a genuine effort is made to explore and communicate the underlying concerns and needs (interests) of the stakeholders participating in the process.

7. **Common Understanding of Problems and Joint Fact Finding**: Time and resources are devoted to developing a common information base among stakeholders.

8. **Policy and Technical Expertise**: Meaningful stakeholder processes require some level of external policy and technical support to accomplish their goals.

9. **Respectful and Authentic Process**: The process is managed so that all are heard and respected. A key role of the collaborative specialist / facilitator is
to manage the dialogue so that the conditions of accuracy, comprehensibility, sincerity, and legitimacy are protected.

10. Transparency of Products: The product needs to accurately reflect the outcome of the stakeholder discussion, in terms of the level of stakeholder support expressed as well as the stakeholder rationale for their recommendation. Specifically, the policy recommendations developed by the stakeholder group clearly state those who support the recommendation, those who oppose and why, those who conditionally support and why, and those who abstain or did not comment and why.

11. Resources: Stakeholder processes need to be funded such that there are appropriate resources to accomplish the above objectives.

If an assessment indicates less than optimal conditions for collaboration, decision makers should either mitigate to improve conditions or select a less intense form of stakeholder engagement. If all indicators point to use of a stakeholder group the next step involves stakeholder selection.

Stakeholder Selection and Criteria

A variety of criteria may be used to select members of a stakeholder group. After creating a stakeholder map to identify the range of interests, several screening questions such as the following may be applied:

- What stakeholders will need to be present for the process to be considered credible?
- To what extent can one set of stakeholders represent the broader interests of others?
- To what extent will this set of stakeholders be needed to achieve a sustainable outcome?

In his recent review of research on successful, effective public participation and stakeholder involvement, 11 William Leach outlined findings on key participant traits. The following is excerpted directly from his report.

Active support and participation by agency staff. Several studies suggest support should from the highest possible levels of the agency. Regular attendance by organization leadership helps legitimize the group and indicates to participants that their contributions will be taken seriously.

11 Leach, William D., Public Involvement and Facilitation Assistance, Center for Collaborative Policy, Sacramento State University, Oct. 2004
Cooperative, enthusiastic, and committed participants. Personal qualities that are especially valued in collaborative settings include honesty and humility, perseverance, a community spirit, a willingness to take risks, to compromise, to listen and learn from others, to keep an open mind, to take criticism gracefully, to respect those with differing opinions, and to avoid attacking others personally.

Trust and social capital. According to stakeholders surveyed in one study, the keys to successful public participation include helping participants “gain insight about others’ views and values” and “improving communication among participants.”

Continuity in participants over time.

Sense of place—a heartfelt affection for and commitment to a geographic location such as a watershed or town. Several studies conclude that it is easier to sustain a successful public participation process when the participants share a strong sense of place.

Strong motivation to resolve the conflict. This motivation can stem from a significant resource problem or crisis, or from a shared recognition that the participants’ interests are interdependent. Motivation is also heightened when participants perceive a political stalemate in which they each lack viable alternatives to the collaborative process.

In addition to the research by Leach our field experience and other studies such as the ones by EPA indicate a few other traits that increase participant effectiveness:

1. Collaborative skills
2. Other skills or expertise useful to the process
3. Leadership ability
4. Degree of legitimacy as a spokesperson for a specific stakeholder community
5. Ability to represent more than one interest
6. Appropriate time and resources to commit
7. Ability to make commitments and reach decisions

A list of desired participant traits may be used by organizations as part of a participant selection processes.

BEST PRACTICES FROM SUCCESSFUL PROCESSES

Leach’s literature review also explored key features of successful stakeholder process and found substantial consistency among all the studies for the following:

12 Leach, William D., Public Involvement and Facilitation Assistance, Center for Collaborative Policy, Sacramento State University, Oct. 2004
- Effective facilitator and/or coordinator.
- Focused scope and realistic objectives. Have clear purpose, goals and objectives. Focus on measurable, quantifiable, or tangible goals. Demonstrate action and not just talk. Work with a manageable number and complexity of projects, having a well-defined geographic scope and making sure that the focus is sufficiently compelling to sustain the participant’s motivation.
- Tractability of the disputes. Careful selection of issues that are appropriate for collaborative planning. Disputes must be negotiable and not driven exclusively by value conflicts.
- Early successes. Early in a process focus on a few easily attainable goals to build momentum, confidence, and reputation. Set both short term and long term goals, and celebrate achieved milestones.
- Early engagement. Act early to receive the public’s comments. Participants are more satisfied when involved in pre-decisional scoping activities, rather than simply commenting on fully formed policy proposals. Use conflict management methods as early in the planning process as possible. Periodically set new goals to maintain the momentum of a partnership.
- Pay attention to the big picture. Focus on more than project implementation. Conduct frequent meetings and frequent communication outside of meetings to maintain relationships.
- Pre-work. Allow facilitators sufficient time to help participants identify their underlying interests and avoid focusing solely on stated policy positions. Successful public participation takes time. Assert the importance of abstaining from judging collaborative processes prematurely.
- Funding. Convening agencies can improve the likelihood of success by ensuring adequate funding is available for various startup costs such as retaining skilled facilitators or conducting situation assessments or public outreach. On the individual participant level, success requires that agencies and organizations and agencies earmark funding to support consistent staff attendance and participation.
- Broad and inclusive participation is desirable. At the same time emphasize the importance of having the right mix of participants to ensure compatible personalities and a diversity of skills and resources.
- Adequate scientific and technical information. To the extent information is beyond the control of the participants, this factor is contextual. However, several process design choices will influence how well any public participation process avails itself of available information. Conveners should solicit both expert knowledge and local knowledge, the latter being frequently overlooked and undervalued. Provide information to help participants achieve common understanding in areas of scientific uncertainty, and design suitable protocols for monitoring and evaluating the outcomes of the process.
- Collaboration skills training is another frequent theme in the literature. Convening staff and other stakeholders are urged to seek out training for
participants in communication, outreach, leadership, & collaborative problem solving skills

- **Well-defined decision rules and process rules.** Some suggestions include: rights and responsibilities of all participants clearly articulated from the beginning; effective process rules, communication rules, or bylaws; a predictable schedule of meetings; and clear duration of the process.

Based on the literature review and anecdotal experiences, not convening a stakeholder process is preferable to a poorly run process. This is because a poorly run process creates unmet expectations that often lead to cynicism and damaged relationships.

**SUMMARY**

Stakeholder processes continue to be used in growing numbers and in various settings ranging from local irrigation and drainage districts to issues of the United Nations. Modern leaders recognize the importance of stakeholders and collaborative process. A variety of techniques, features and criteria may be used to determine the best course for a collaborative. Four primary recommendations can be drawn from this paper:

1. Engage the right stakeholders as early as possible
2. Select the appropriate public processes
3. Use best practices drawn from other successful efforts
4. Adequately support the process.
Planning For Extreme and Prolonged Drought Conditions
Planning for Extreme and Prolonged Drought Conditions

Water managers today use hydrologic records of the past century to estimate how climatic conditions would affect future water availability and water needs. Planners take into account the normal fluctuations of wet and dry years in allocating deliveries from reservoirs and in determining how much water will be provided from other sources. Because the state has also experienced extreme and prolonged droughts, the most recent one occurring from 1987 to 1992, many local water agencies have developed drought contingency plans for such rare but extreme conditions that can result in significant socio economic and environmental impacts. The State has provided drought assistance to local water agencies and homeowners with the implementation of Proposition 50, Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002.

Since the last drought (1987-1992) the following notable changes have occurred that would change the demand and supply. Population of California has increased by more than 6 million by year 2001, which will cause additional stress on the available water supply while completion of construction of Coastal Aqueduct (Department of Water Resources), Morongo basin pipelines (Mojave Water Agency), Diamond Valley Lake (Metropolitan Water district), Los Vaqueros Reservoir (Contra Costa Water District) and five large scale groundwater recharge/storage projects should add flexibility in operating the water system. Planers should take into account these conditions when planning for another prolonged drought.

**Historical Perspective**

The most severe recorded drought occurred in 1976-1997. Two consecutive years with little precipitation (fourth driest and the driest year in the recorded history) left California with record low storage in its surface reservoirs and groundwater levels dangerously lowered. Socioeconomic and environmental impacts were very severe during these extreme drought conditions. The total loss due to the drought during these two years exceeded $2.5 billion ($6.5 billion at today’s cost).

The most recent prolonged drought lasted six years from 1987-1992. During the first 5 years of the drought, in San Joaquin valley the groundwater extractions exceeded the recharge by 11 million acre-feet which caused increased land subsidence in some areas. Department of Water Resources (DWR) studies indicate that in 1990-92, the drought resulted in reduced gross revenues of about $670 million to California agriculture. Energy utilities were forced to substitute hydroelectric power with more costly fossil-fuel generation at an estimated statewide cost of $500 million in 1991. The drought also adversely affected snow-related recreation businesses. Some studies suggest as much as an $85-million loss for snow-related recreation businesses during the winter of 1990-91.

**Drought Contingency Planning**

Several drought contingency planning reports are already published at state and regional levels, some of which as a result of Legislature. Three bills enacted by the Legislature to improve water supply planning processes at the local level became effective January 1, 2002. In general, the new laws are intended to improve the assessment of water supplies during the local planning process before land use projects that depend on water are approved. The new laws require the verification of sufficient water supplies as a
condition for approving developments, and they compel urban water suppliers to provide more information on the reliability of groundwater if used as a supply. Normal and drought year conditions are specified in the law when evaluating water supply reliability.

**SB 221** (Bus. and Prof. Code, § 11010 as amended; Gov. Code, § 65867.5 as amended; Gov. Code, §§ 66455.3 and 66473.7) prohibits approval of subdivisions consisting of more than 500 dwelling units unless there is verification of sufficient water supplies for the project from the applicable water supplier(s). This requirement also applies to increases of 10 percent or more of service connections for public water systems with less than 500 service connections. The law defines criteria for determining "sufficient water supply, such as using normal, single-dry, and multiple-dry year hydrology and identifying the amount of water that the supplier can reasonably rely on to meet existing and future planned uses. Rights to extract additional groundwater must be substantiated if used for the project.

**SB 610** (Water Code, §§ 10631, 10656, 10910, 10911, 10912, and 10915 as amended; Pub. Resources Code, § 21151.9 as amended) and **AB 901** (Water Code, §§10610.2 and 10631 as amended; Water Code § 10634) make changes to the Urban Water Management Planning Act to require additional information in Urban Water Management Plans (UWMP) if groundwater is identified as a source available to the supplier. Required information includes a copy of any groundwater management plan adopted by the supplier, proof that the developer or agency has rights to the groundwater, a copy of the adjudication order or decree for adjudicated basins, and if not adjudicated, whether the basin has been identified as being overdrafted or projected to be overdrafted in the most current DWR publication on the basin. If the basin is in overdraft, the UWMP must include current efforts to eliminate any long-term overdraft. A key provision in SB 610 requires that any project subject to the California Environmental Quality Act supplied with water from a public water system be provided a water supply assessment, except as specified in the law. AB 901 requires the plan to include information relating to the quality of existing sources of water available to an urban water supplier over given periods and include the manner in which water quality affects water management strategies and supply reliability.

California voters approved the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002 (Proposition 50; Water Code, § 79500 et seq.) in November 2002. The initiative provides for more than $3.4 billion of funding, subject to appropriation by the Legislature, for a number of land protection and water management activities. Several chapters of Proposition 50 allocate funds for specified water supply and water quality projects, including Chapter 3 Water Security. It provides $50 million to protect State, local and regional drinking water systems from terrorist attack or deliberate acts of destruction or degradation.

**Local and Regional Efforts**

The urban Water Management Act requires that each urban water agency which serves more than 3,000 people or 3,000 acre-feet per year, to prepare its own water management plan once in every five years. The urban water management plan includes an analysis and a contingency plan for water supply reliability in face of a severe drought which includes up to 50 percent reduction in water supply. Water management plans lay out shortage contingency scenarios that districts will use as guide lines when reducing demand and augmenting short term supply. Long- and short-term conservation measures,
recycling water, water transfers, short-term sources of water, and long term storage including conjunctive use are some of the tools that water districts use to plan against a multi year drought

State Efforts

The Governor's Advisory Drought Planning Panel was formed in 2000 to develop a contingency plan to address the impacts of critical water shortages in California. The panel formed with the recognition that critical water shortages may severely impact the health, welfare, and economy of California. In its July 2000 report, “Preparing for California’s Next Drought,” the department reviewed items for near-term drought planning, putting California’s conditions today into perspective with experiences gained in the 1987-92 drought. Major findings of the report focused on the characterization of drought conditions as a gradual phenomenon and as a function of impacts on water users. The report also addressed the vulnerability of existing water users based on past droughts, and a discussion of current actions that affect drought preparedness planning.

As part of a five year planning program to implement specific actions of the CALFED Bay-Delta Program, a Governor’s Drought Panel, in its December 2000 report, “The Critical Water Shortages Contingency Plan,” made recommendations for actions that the State government could take to reduce the impacts of critical water shortages. The recommendations included a critical water shortage reduction marketing program to facilitate intra-regional, short term, and dry year transfers, financial and planning assistance to local agencies for drought-related response activities, and assistance to small water Systems and homeowners in rural counties. The work on these programs started early 2002 and is still ongoing through bond measures Proposition 13 (March 2000) and Proposition 50 (November 2002).

Governor’s Advisory Drought Planning Panel (2000)

The CALFED Record of Decision (August 2000) called for the governor to convene a panel, chaired by the director of DWR, to develop a contingency plan for reducing impacts of critical water shortages in the next several years while the actions identified in CALFED's Stage 1 were being planned and implemented. The Governor's Advisory Drought Planning Panel identified a variety of physical, regulatory, and institutional challenges to effective water management during times of critical water shortages.

The panel intended the following recommendations to be statewide in scope, applying to any areas of the State that may benefit from them. Nothing in the recommendations is intended to limit their geographical scope to CALFED study areas. The panel did not intend that its recommendations duplicate actions already scheduled for early implementation in the ROD, but rather suggests that ROD actions and the panel’s recommended actions be coordinated, as much as possible, to maximize their benefits.

A. Critical Water Shortage Reduction Marketing Program. The panel recognized that the CALFED agencies were tasked with streamlining the water transfer process. In addition to the CALFED actions, the panel recommended that DWR implement a Critical Water Shortage Reduction Marketing Program. The program would be operated as an as-needed water purchasing and allocation program using a three-tiered methodology. Tier 1 would consist of water shortage preparedness activities undertaken by State and local agencies. Tier 2 would consist of purchasing options and allocating water to communities that have maximized their own resources. Tier 3 would be implemented during a water shortage emergency and would include continued implementation of Tier 2 actions, plus extraordinary measures needed to protect public health and safety, such as State
financial assistance for water hauling, pipeline construction, or well drilling. DWR would acquire options to purchase water from willing sellers and would exercise the options as needed to make water available for sale to water users experiencing critical water shortages. The panel further recommended that the governor propose, and that the Legislature provide, a General Fund appropriation for preparing a programmatic EIR for Critical Water Shortage Reduction Marketing Program.

B. Assistance to Small Water Systems and Homeowners in Rural Counties. The panel recommended that DWR develop a technical assistance and education program targeted at rural homeowners and small domestic water systems relying on self-supplied groundwater, to be implemented in consultation with rural county environmental health departments. The panel further recommended that the governor propose, and that the Legislature provide, an annual appropriation of at least $1.5 million from the State General Fund to support this program. The program would include workshops to educate homeowners; a website containing information on State and county well construction requirements, sources of groundwater level and well yield data; and requirements for informing potential home buyers of the groundwater and well conditions and risks.

C. Local Agency Groundwater Programs. The panel recommended that DWR establish an AB 3030 technical assistance program, following the process established in Water Code Section 10795 et seq. The panel further recommended that the governor propose, and that the Legislature provide, an appropriation from the State General Fund of at least $5 million per year to implement the program. In addition, the panel also recommended that the governor propose, and that the Legislature provide, an appropriation of $1 million annually from the State General Fund to provide for ongoing statewide groundwater data collection and compilation (including geohydrologic and water quality data), and that DWR publish this information every five years as updates to Bulletin 118.

D. Local Agency Integrated Water Management Plans. The panel recommended that DWR and other CALFED agencies work in partnership with local water agencies to assist them in developing plans to facilitate integrated management of supplies for agricultural, urban, and environmental purposes. The panel further recommended that DWR provide financial assistance, in the amount of at least $2 million per year from a combination of General Fund, Proposition 204, or Proposition 13 monies to local agencies for preparing integrated water management plans.

E. Drought-Related Research and Public Outreach Activities. The panel recommended that DWR identify and seek funding for research in the areas of long-range weather forecasting, global climate change, and paleoclimatology. The panel recommended that DWR compile existing local agency drought watch indices and develop regional hydrologic drought indices for watersheds important to statewide water supply conditions and watersheds supporting significant urban and agricultural development. The panel also recommended that DWR develop a public outreach program to stress the need for drought preparedness, building on the recommendations of the May 2000 report of the National Drought Policy Commission.

F. Accelerate Proposition 13 Financial Assistance to Local Agencies. The panel urged the governor to take all possible actions to ensure rapid disbursement of Proposition 13 funds, including out-of-State recruitment for new staff, statutory waiver of Water Code requirements for review of DWR rules and regulations by the California Water Commission, and expediting or statutory waiver of Office of Administrative Law review of rules and regulations. The panel further recommended that bond monies applicable to CALFED actions be budgeted as quickly as possible, and that DWR maximize use of grants, rather than capitalization loans, to bring local agencies up to the base level of efficiency contemplated in the CALFED ROD.
DWR has implemented many individual actions aimed at meeting these recommendations. A few examples include:

- Operated a dry year water purchasing program
- Held educational workshops for private well owners
- Convened the Small Water System Drought Preparedness Advisory Committee
- Conducted a competitive selection process for grants for preparation of groundwater management plans
- Installed production wells in the Klamath Basin
- Installed monitoring wells in Mendocino County
- Developed a drought preparedness web site
- Co-sponsored an academic conference on droughts

**Responding to Future Droughts**

In planning for future water supplies and needs, the hydrology of the past century may not be a reasonable measure of the climate in Northern California. The flow record available for California is rather short for determining hydrologic risks, extending back only about 100 years with mostly qualitative information perhaps for another 100 years. Past tree ring studies have shown extensive dry periods far exceeding the six-year maximum that was recorded in the last century. For potential significant reductions to the Sierra snow pack from climate change as it may affect current hydrology is discussed under global climate change.
Planning Framework for Water Plan Update
By Lisa Beutler and David Sumi, Center for Collaborative Policy, California State University, Sacramento
Planning Framework for California Water Plan Update

By Lisa Beutler and David Sumi, Center for Collaborative Policy, California State University, Sacramento

State Water Code directs the Department of Water Resources (DWR) to prepare periodic California Water Plan Updates. The 2005 update departs from previous efforts by incorporating a new planning framework. Working with an active 65-member advisory committee and an almost 400-member Extended Review Forum, DWR sought to increase the Update’s relevance, utility and usefulness.

The advisory committee is composed of representatives from agriculture, urban water districts, businesses, environmentalists, Native Americans, environmental justice advocates, cities, counties, federal and State agencies, the California Bay Delta Authority, academia, and different regions of the State. Both DWR and the advisory committee find the new framework to be one of the significant accomplishments of this water plan update. With built in initial support, the approach serves as a cornerstone for future updates.

The new framework will be easier for decision makers at all levels of government to adopt because it considerably expands public involvement and access to the State’s water planning process. This approach provides more robust, collaborative recommendations and greater longevity; provides more utility and options for resource managers; and, results in a strategic plan. It also serves as a living document with stated goals, objectives, and implementation plan, including progress tracking, indicators and reports. The approach consists of:

- Phased planning
- Collaborative planning process
- Comprehensive way for describing current and future water supplies, uses and management (Water Portfolios with over 80 categories) using actual data (not trend-based) for recent yet different water year types, namely 1998 (wet), 2000 (average), and 2001 (drier)
- Detailed reports on each of the regions of the State
- Multiple scenarios for plausible futures (not a single “likely” future) to identify and minimize future uncertainties and risks
- Many diverse resource management strategies to meet future water demands while sustaining our resource base and economy

**Phased Planning**

In this Update, DWR achieves Water Code requirements through a phased work plan that also develops analytical tools and acquires data for the next California Water Plan Update. (See Box 1-2 Legal Requirements for California Water Plan and Volume 4 Reference Guide article “Work Plan for Meeting Legal Requirements for the California Water Plan.”) New information will help regional and local agencies in integrated water resource management. The plan phases follow:

- **Phase 1:** Distribute the Public Review Draft of California Water Plan Update 2005, a five-volume publication. This water plan update is based on the best available data and information and input...
from an active and diverse advisory committee. Update 2005 recommends policy and priorities, documents gaps in data and analytical tools, and describes an approach for future quantitative analysis. (Phase 1 is complete.)

- **Phase 2:** Started in 2004 this phase provides a final California Water Plan Update 2005 with revised policy recommendations based on broad public input and numerous public hearings. Phase 2 also documents the data, analytical tools, methods, and assumptions DWR will use in Phase 3. (Phase 2 is complete with publication of this document.)

- **Phase 3:** Phase 3 begins in 2006 when DWR initiates the process for the next California Water Plan Update with participation of a broad public advisory committee. DWR will begin to quantify and evaluate 3 future scenarios and alternative management responses using the data and tools identified in Phase 2. A water flow diagram will present evaluation results for wet and dry year conditions, and a California Department of Food and Agriculture food forecast will be used to estimate future irrigated crop water use. As part of an ongoing strategic planning process, DWR will present Phase 3 evaluations to the public as they become available. The California Water Plan Update 2005 strategic plan findings, recommendations, and the implementation plan will be reviewed and revised periodically.

- **Other:** Although DWR will continuously refresh and add plan data and information, five additional point-in-time, five-year water plan updates will be produced during the twenty-five year (2030) planning horizon.

**Collaborative Planning**

This update recognizes the vital importance of working with key stakeholders to define issues, identify potential approaches, and evaluate planning steps. Since January 2001 DWR and an advisory committee representing critical sectors with an interest in water management have worked to shape the new planning framework and strategic planning process. Using large group meetings held roughly every six weeks for three years, more frequent smaller work groups and workshops, and many public briefings, DWR sought a broadly informed and consensus-seeking process. Advisory committee members provided the Department with substantial suggestions and recommendations on all aspects of the California Water Plan Update 2005.

**Collaboration Statistics**

<table>
<thead>
<tr>
<th>Type of Meeting</th>
<th>Meetings</th>
<th>Person hours</th>
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<tr>
<td>Advisory committee</td>
<td>43</td>
<td>12,681</td>
</tr>
<tr>
<td>Extended review forum &amp; organizational briefings</td>
<td>43</td>
<td>1,558</td>
</tr>
<tr>
<td>Workshops</td>
<td>43</td>
<td>3,161</td>
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<tr>
<td>2005 Public comment workshops</td>
<td>15</td>
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</tr>
<tr>
<td>Work groups</td>
<td>62</td>
<td>4,271</td>
</tr>
<tr>
<td>Tribal outreach</td>
<td>7</td>
<td>69</td>
</tr>
<tr>
<td>Totals</td>
<td>197</td>
<td>23,252</td>
</tr>
</tbody>
</table>

*Tables figures are valid through September 2005.

Created by statute and composed with diverse perspectives, the advisory committee represented the interests of all Californians and the natural environment. The group provided DWR with suggestions and
conclusions on every aspect of the water plan update, including developing goals and strategies for water management in California.

Outreach and Decision Process

To create a fair, open and transparent process, the California State University Sacramento, Center for Collaborative Policy (CCP) provided impartial third party facilitation and mediation design, implementation, and refinement for the consensus-seeking process. The Center ensured advisory committee members’ interests, views, and opinions were thoughtfully considered and the advisory committee activities were governed by its own operating guidelines.

The advisory committee strove to reach consensus on the purpose, content, and process of the water plan update. While DWR sought advisory committee full agreement and support on every issue, time did not permit resolution of all fundamental concerns. The CCP facilitation teams captured the range of support and opposition to proposals. DWR then considered the range of perspectives and made final decisions. Those suggestions approaching consensus received the highest possible consideration for incorporation into the update.

As part of their membership obligations, advisory committee members periodically briefed their constituencies on key developments. Members relayed comments received during these briefings to DWR. The briefing process helped ensure two-way communication between members and their organizations. In addition, briefings formally expanded the dialogue beyond the precincts of the advisory committee meeting room into a wider audience of potential users of California Water Plan Update 2005.

With coordination from the Center, the advisory committee produced the Advisory Committee View, a four-page newsletter-like document that summarized areas of agreement, disagreement, and uncertainty that had been raised during the four-and-a-half year advisory committee process. This document, carefully negotiated and approved by the different interest caucuses of the advisory committee, helped to inform the public and DWR on key issues during the comment period of the Public Review Draft of the California Water Plan Update 2005. The Advisory Committee Review can be found in the Background section of Volume 4: Reference Guide.

In addition to the formal advisory body, an Extended Review Forum, composed of individuals with a high interest in the process attended periodic briefings and received invitations to advisory committee and work group meetings as well as updates on key developments. With nearly 400 members, this group represents an even broader range of interests than the advisory committee. DWR also used other forums to engage other State, federal, and local government representatives, local water interests, the public, and media. DWR periodically briefed the Governor’s Office, Legislature, and the Resources Agency on the process.

The Internet provided another principal venue for advisory committee work. In its efforts to create an open and transparent public process, DWR used e-government technology to set up web pages and electronic surveys, and used email correspondence and teleconferencing whenever possible. DWR posted meeting agendas, materials, and highlights, including draft copies of California Water Plan Update 2005, for all to see. DWR also posted numerical data for the water portfolios and documentation on the web site for use by advisory committee members and other interested parties.
Continuous Improvement

In tandem with the strategic planning process, DWR conducted surveys with California Water Plan customers, the people who use the plan for various purposes. The intention was to make Update 2005 widely understood and useful. The survey expanded the traditional water plan audience of government, private, and nonprofit entities to include land use planners, natural resources planners, environmental and social advocacy groups, business sectors (for example, agricultural, real estate, financing), professional associations, academic institutions, water planners, wholesalers and retailers, and similar individuals and groups.

The survey indicates the planning horizon for most users is 2010. The issues of interests for evaluation parallel the advisory committee’s, including water quality, cost, reliability, and environmental impacts. Major issues of concern are water quality, reliability, and land use planning.

In addition to the customer survey, the CCP conducted several stakeholder assessments with advisory committee members throughout the process. These served as feedback mechanisms for identifying issues for DWR to consider in California Water Plan Update 2005, assessing staff progress for the work at hand, modifying meeting methods, and improving communication between DWR and the advisory committee itself.

The Public Review Draft formal comment period lasted from April 14, 2005 to July 22, 2005 to allow substantial time for public review. During June and July 2005, DWR held 13 public input workshops in 12 cities throughout different regions of the state. In addition to 11 daytime workshops, DWR also offered 2 evening workshops and 2 evening toll-free teleconference briefings out of consideration to members of the public who might not be able to attend during normal business hours. 250 members of the public attended these workshops. The public comment process was generally well received. The workshop format encouraged interactive education and discussion, as well as formal statements. Most participants appreciated the workshop format and contributed their comments in table discussion. A hearing period was reserved at the end of each workshop for individuals to give formal oral statements.

Members of the California Water Plan Update 2005 advisory committee played a critical role at the public comment workshops, providing credibility, sharing insights, and urging the public to attend and to participate. The Advisory Committee View document handout provided common talking points across meetings and informed the discussion with an articulated and balanced range of perspectives.

In addition to feedback received at the 13 public input workshops, DWR received 139 written comments via postal mail, fax, e-mail, and an online comment form on its website during the public comment period. All written comments, as well as meeting summaries for all public comment workshops, were posted on the Water Plan website for public view.

The construction of a systematic approach for collaborative water planning is an investment. With the foundation now in place, future water plan updates will be able to have an accelerated start in setting up advisory committees, establishing protocols and initiating planning approaches.
Strategic Planning Guidelines
By California Department of Finance staff
Strategic Planning Guidelines

To:
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Published by the California State Department of Finance

Revised: May 1998
ACKNOWLEDGMENTS

In preparing these guidelines, the Department of Finance reviewed numerous publications, books, and plans for other organizations/governments. The primary references used are listed in Appendix E. From these references, we have incorporated practical and informative materials and text to assist state agencies.
**INTRODUCTION**

*Strategic Planning Guidelines* has been prepared to assist agencies1 in understanding the strategic planning process. After addressing the overview of what planning is, the guidelines provide a framework to help an agency to develop its own strategic plan and to define performance measures that emphasize meaningful results. It is intended to serve as a continuing reference document for agencies.

The appendices summarize the basic process for agency strategic planning, set forth the instructions for the submission of each agency’s Strategic Plan by July 1, 1998, and indicate various helps and references including a glossary of selected planning terms.

All California state agencies are required to have an approved strategic plan by July 1, 1997. The annual strategic plan survey, identifying those agencies with a strategic plan, will continue to be taken each February, with the resulting report sent to the Governor and the Joint Legislative Budget Committee (JLBC). Statute requires that agencies without a strategic plan during the prior year’s survey must report each April 1 to the Governor and the JLBC.

Beginning with preparation of the Fiscal Year 1998-99 budget, strategic plans will be linked to the budget process. Henceforth, all budget change proposals, including those for capital outlay, will be considered for approval only when an agency has an approved strategic plan and the request will be required to be consistent with that plan. Although a strategic plan is not a budget request, the projected levels of goal achievement should be commensurate with anticipated resource levels.

An agency should consider the prospective readership of its strategic plan when determining length, style, and understandability. The presentation and effort should be commensurate with the size and complexity of an agency.

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1 Throughout the guidelines, the term “agency” is used to refer to a State agency, department, board, commission, or office.
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STRATEGIC PLANNING GUIDELINES

Planning

Purpose of Planning. “The purpose of planning is to improve the chances of reaching desirable possible outcomes. The benefits of planning enable an organization to:

(1) prepare for contingencies that could prevent it from attaining its goals,
(2) prepare a framework for the organization’s orderly growth and progress, and
(3) have a strategy for the allocation of resources in a manner that will allow the organization to meet its goals.”

“In California, some State government departments do not plan at all, asserting the nature of their statutory responsibilities such as providing information or regulatory enforcement. Others do plan, but only because they may be statutorily required to do so. Yet others plan not so much because they have to, but because they see the inherent value in having a systematic strategy in place to meet their long range goals, objectives, and needs.”

“Correspondingly, the only State agency that need not plan would be an agency that has no long-range needs or goals to satisfy. In turn, an agency that has no long-range needs may not need to exist in the longer term.” (Appendix E, reference #2, page 4)

Background. The Governor’s Interagency Council on Growth Management found in 1992 that:

“A variety of different kinds of plans exist. Comprehensive or Master Plans provide a comprehensive overview of a function, are long range, and set forth an agency’s policy. Facilities Plans set forth agency objectives to maintain, locate and expand facilities under its responsibility. Strategic Plans, visionary and also long-range in approach, set forth the most feasible methods of implementing policies. Some strategic plans carry the misnomer of master plan, unfortunately. Operational Plans set forth an agency’s staffing, budget, and resource allocations. Policy Plans, often times components of strategic plans, set forth a department’s conceptual policies without necessarily indicating specific measures for their attainment or methods of evaluation. All serve as functional plans which, as defined in Government Code Section 65026, are intermediate- or short-range plans for the operation of a State...
governmental discrete function. State departments select the type of plan not only on the basis of finding the best approach to meet goals, but also because statutes occasionally dictate certain elements of a plan’s format and the particular requirements to be fulfilled.”
(Appendix E, reference #2, page 19)

The California State Administrative Manual (SAM) Sections 1100 through 1107 address the State Plan Preparation and Review Process. These sections also discuss relevant sections of statutes, as well as set forth the administrative steps to the planning process.

In 1994, the California State Legislature enacted, and Governor Wilson approved, the State Government Strategic Planning and Performance Review Act (Chapter 779, Statutes of 1994). This legislation requires the Department of Finance (DOF) to annually survey agencies to obtain specified information concerning strategic plans and to recommend which agencies should develop or update a strategic plan. It also requires the DOF to develop a plan for conducting performance reviews of state agencies that have completed strategic plans.

In 1996, as part of its Chapter 779 report, the DOF recommended that all agencies have a strategic plan. Subsequently, Management Memo 96-23 was issued to mandate this requirement that all state agencies have a strategic plan.

What is a Strategic Plan. A strategic plan is a practical action-oriented guide, based on an examination of internal and external factors, which directs goal-setting and resource allocation to achieve meaningful results over time.

A strategic plan develops a clear statement of the agency’s mission and vision, identifies a set of goals and objectives and formulates key strategies that address those factors that are essential to the agency’s success. Key strategies also indicate the major undertakings that will reposition the agency for the future.

A plan should address the agency’s reengineering of the business process. This reengineering is the search for, and implementation of, radical changes in business processes that result in dramatic efficiencies, reductions in turnaround time, improvements in quality, or improvements in customer service.

Components of a Strategic Plan. There are several key components that are usually included in a plan; these include the internal/external assessment, mission statement, principles, vision, goals, objectives, performance measures, and action plans. Additionally, there are specific steps to be taken to (a) develop and implement the plan, and (b) track and monitor progress. However, it is generally recognized that the comprehensive process used to create the strategic plan is more useful to the agency than the plan itself.
**STRATEGIC PLANNING**

**What is Strategic Planning?** Strategic planning is managing for results. It is defined as a long-term, future-oriented process of assessment, goal setting, and strategy building that maps an explicit path between the present and a vision of the future, that relies on careful consideration of an organization’s capabilities and environment, and leads to priority-based resource allocation and other decisions. It is a disciplined effort to produce fundamental decisions and actions that shape and guide what an agency is, what it does, and why it does it. It includes the process of developing a strategic plan. A strategic plan is an agency’s comprehensive plan to address its business needs; i.e., to successfully carry out its programmatic mission. Because strategic planning is a team effort that builds consensus on a future direction for an agency, the process itself is more important than the resulting document.

The California State Government Strategic Planning and Performance Review Act (Chapter 779, Statues of 1994) finds that “strategic planning is a prerequisite for effective performance review and performance budgeting.”

*Strategic planning is an essential tool.* Strategic planning determines the things that an agency can do to address customer expectations. Agencies are constantly challenged to manage complex and changing problems with limited resources. Administrators must address new as well as ongoing responsibilities while containing and even reducing costs. Further, agencies are being asked to focus on achieving results and stretching those results each year so that more work is done, work is performed better, and/or work is done faster. In other words, results should focus on the efficiency and effectiveness of agency operations.

*Strategic planning is adaptable.* Strategic planning takes a long-range approach, but can use regular reviews and updates to check progress and reassess the validity of the plan based on strategic issues uncovered in the internal/external assessment. The plan can be updated to make the adjustments necessary to respond to changing circumstances and take advantage of emerging opportunities. It sets targets for performance, incorporates ways to check progress, and provides guidance for on-going operational and capital plans and budgets.

*Strategic planning is planning for change in increasingly complex environments.* Perhaps the one constant in State government today is the notion of change. Increasing demands for services, shrinking resource bases, and greater expectations for service all combine to form a dynamic environment. Strategic planning is proactive, it stimulates change rather than simply reacting to it.

**Key Point**

“If you fail to plan, you plan to fail.”
Strategic planning employs common sense. Strategic planning is visionary yet realistic; it anticipates a future that is both desirable and achievable. It provides a structure for inspired, but practical, decision-making and follow-through.

Strategic planning is part of quality management. It helps the executive to manage the future, rather than be managed by it. It involves a disciplined effort to help shape and guide what an agency becomes, what it does, and why it does it. Strategic planning requires broad-scale information gathering, an exploration of alternatives, and an emphasis on the future implications of present decisions. It facilitates communication and participation, accommodates divergent interests and values, and fosters orderly decision-making and successful implementation.

Why isn’t this long-range planning? Strategic planning and long-range planning are different in practice.

- Strategic planning relies heavily on identifying and resolving issues, while long-range planning focuses more on specifying goals and objectives and translating them into current budgets and work programs.
- Strategic planning emphasizes assessment of the environment outside and inside the agency far more than long-range planning does.
- Strategic plans embody qualitative shifts in direction and include a broader range of contingency plans, while long-range plans typically are linear extrapolations of the present. Strategic planners usually consider a range of possible futures and focus on the implications of present decisions and actions in relation to that range. Long-range planners tend to assume a most likely future, and then work backward to map out the sequence of decisions and actions necessary to reach the assumed future.
- Strategic planning is much more action oriented than long-range planning.

Strategic planning is a complex undertaking, requiring the active participation of all levels of agency management. Agency leadership should take an active role in strategic planning and performance measurement, including formulation and improvement of their agency’s performance management systems. Program managers, however, should have a major role in identifying these elements as they pertain to their own programs. Success involves a thoughtful combination of visionary creativity and rigorous analysis, tempered by a keen appreciation of technological possibilities and political and economic realities.

Key Point

It is essential to recognize what strategic planning is not. It is NOT a quick fix. Like many quality management efforts, it is a long-term investment with payoffs that increase over time. Planning is not a magic wand; saying something does not make it so. In other words, any plan must be accompanied by commitment and action if it is to achieve results.
In simple terms, strategic planning helps an agency ask four basic questions:

WHERE ARE WE NOW?
WHERE DO WE WANT TO BE?
HOW DO WE GET THERE?
HOW DO WE MEASURE OUR PROGRESS?

Strategic planning is managing for results. It is a participatory process which requires the full support of the agency director. Top management should make a firm commitment to support the planning effort by providing resources for that effort. The head of the agency should assign individuals to the task of formulating an integrated plan.

Strategic planning considers the needs and expectations of customers and stakeholders (including policy-makers) in defining missions, goals, and performance measures.

**THE STRATEGIC MANAGEMENT CYCLE**

**Program Evaluation**  
**Strategic/Quality Planning**  
**Results**  
**Budgeting**  
**Performance Monitoring and Reporting**  
**Program Implementation**

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**Note**

In practice, the cycle may not be sequential. This illustration is designed to illustrate the interrelationship between key components.

Source: State of Arizona’s Strategic Planning and Performance Management Handbook, “Managing for Results”
**Relationship of Strategic Planning to Other Management/Planning Systems**

Strategic management is the process of positioning an agency so it can prosper in the future. Strategic management integrates strategic planning with other management systems. As shown on the above illustration, “The Strategic Management Cycle,” it can link strategic/quality planning, budgeting, program implementation, performance monitoring and reporting, and program evaluation. In practice, strategic management may not be sequential, but there are strong interrelationships between the various key components. The links between strategic planning and these other management systems are further described below.

**Quality Management.** Strategic planning works best in an atmosphere of quality management. Ideally, strategic planning is integrated with quality concepts. However, strategic planning can also be successfully employed as the vehicle to introduce quality concepts and efforts. Strategic planning and quality management share many elements; therefore, these guidelines strive to integrate strategic planning and quality concepts and techniques.

Total Quality Management (TQM) is a management approach that values customer satisfaction. TQM is based on participation of all members of an agency in improving the processes, products, services and culture in which they work. In employing TQM, agencies must be careful not to focus too much on the improvements themselves, but rather on how to improve processes, because improvement is a continuous process. The emphasis of TQM is on continuous improvement rather than a one-time fix.

The fundamental elements of quality management and strategic planning are the same. Both are systematic approaches to identifying problems and opportunities that:

- promote customer-focused services and products
- emphasize employee involvement and teamwork
- use performance measurements
- focus on results
- rely on data collection and interpretation
- support management that is based on facts
- involve efficient and effective resource allocation and management

Like strategic planning, quality management cannot succeed without the commitment and support of top management. Successful implementation of both the principles of TQM and strategic planning requires a vision, planning,
and active involvement from agency top management. In addition, it needs management’s practical support through continuous training and education, time, money, and personnel. In fact, indifference and lack of involvement by top management are frequently cited as the primary reasons for the failure of TQM and strategic planning endeavors.

Fortunately, more and more agencies are recognizing the benefits of TQM and are using TQM as a strategy to achieve their agency goals and objectives. TQM has gained popularity as the “method-of-choice” primarily because it is designed to improve work quality, customer satisfaction, and employee morale. TQM can also increase productivity, empower employees, and reduce bureaucracy by eliminating duplications and streamlining work processes.

**Budgeting.** Strategic planning and budgeting are integral components of good management. The strategic plan charts direction, while the budget provides resources to implement the plan. A strategic plan neither grounded in fiscal reality nor linked to the budget would be only a dream. On the other hand, resource allocation without strategic thinking would be shortsighted and unresponsive to future conditions.

Strategic planning guides the budget process. It establishes and affords management an opportunity to reevaluate existing allocations of funds. Agencies can develop strategies and action plans that detail what will be accomplished to achieve strategic planning goals and objectives each year. These action plans, together with performance measures, provide the strongest links between the operating and capital outlay budgets.

Planning and budgeting are interactive. Assumptions about available resources affect what can be achieved in the plan; the plan also sets priorities for resource allocations. Since government funding continues to be limited, strategic planning can help agencies as they strive to “do more with less” while remaining focused on results.

The Internal/External Assessment component of the strategic planning process can be valuable in identifying trends, demand factors, and strategic issues to support budget development. Well-conceived strategic plans, with missions and goals that emphasize accomplishment of meaningful results in a constrained fiscal environment provide strong justification for resource allocation.

**Human Resources, Training and Workforce Development.** Executive Order W-151-97, issued March 31, 1997, stipulates that models for integrating workforce development programs into organizational strategic plans shall be defined. Consistent with that order, strategic plans shall address human resources elements where appropriate, beginning with those plans submitted for approval in 1998.

State agency strategic plans, in addressing human resources planning needs, may include one or more human resources topics such as: 1) changes in work design and/or organization; 2) recruitment and planned demographic

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changes; 3) changes in classification and pay, etc.; or 4) employee development, education and training.

Human resource issues can be addressed through a variety of means consistent with your state agency’s planning model and at the appropriate level of the plan. For example, workforce development initiatives, such as training, may be encompassed within a strategic direction set forth by the state agency, or may be identified and tracked through a specific performance measure. Under performance budget models, outcomes should be identified and measured.

All state agencies should keep their DOF budget analyst and Department of Personnel Administration (DPA) classification analyst informed of their strategic planning and human resource/workforce development planning efforts.

The DPA will issue additional guidance to assist state agencies in bringing human resource and workforce development elements into the strategic planning process.

**Information Technology Management.** Information technology resources include, but are not limited to, computer equipment, software, communications, applications, and consulting services.

The Agency Information Management Strategy (AIMS) must be consistent with, and subordinate to, the overall agency strategic plan. (State Administrative Manual Sections 4900 through 4900.7 address Information Technology Information Management Planning, including the AIMS.)

**Program Monitoring and Reporting.** A critical component of the strategic management cycle is the monitoring and reporting of progress in achieving strategic goals. Agencies are encouraged to develop monitoring and reporting systems that collect data continuously and report annually, at a minimum. The performance information from the agency’s strategic plan provides a basis for reporting progress to external policy makers and the public. Agency annual reports provide an opportunity to report progress on planned accomplishments.

**Program Evaluation.** Agencies are encouraged to incorporate program evaluation as an ongoing process within their agency.

**Federal Government Performance and Results Act of 1993.** In 1993, the Government Performance and Results Act (Public Law 103-62) was enacted. The purpose of this Act is to improve performance accountability in the federal government. The law establishes a pilot program for federal agencies to develop strategic plans and performance measures. Some State agencies which receive funding from the federal government have been asked to provide planning and performance information to federal agencies. This link between state and federal efforts to achieve greater performance accountability may become stronger in the future.
Features of Successful Strategic Planning

A successful strategic planning process has the following characteristics:

♦ It has the full support of the agency director.
♦ It is flexible. It fits the agency. It is user friendly.
♦ It is participatory. It involves executives, managers, supervisors, and staff at all levels; it gives each of them a “piece of the action.”
♦ It is not left to planners; everyone plans.
♦ It clearly defines responsibilities and timetables. It is carried out by those who have the responsibility within the agency for achieving objectives, but is coordinated by a central figure; someone who has the “big picture.”
♦ It galvanizes an agency; it produces understanding and common purpose throughout an agency.
♦ It stays aware of the environment in which it functions. It obtains perspectives from many levels and sources, both within and outside the agency.
♦ It is realistic about goals, objectives, resources, and outcomes. It takes personnel issues, overall fiscal conditions, and budgetary trends into account.
♦ It is politically sensitive.
♦ It is convincing. It develops and conveys compelling evidence for its recommendations. It uses innovative communications strategies.
♦ It has a method or strategy for resolving conflicts among stakeholders.
♦ It establishes and ensures accountability for results.
♦ It leads to resource decisions and acknowledges the reality of having to do more with less, often requiring tradeoffs or the redirection of resources.
♦ It is fresh and continuous, not stale and static. Both the plan and the planning process are reviewed and modified regularly (usually annually).

We are discussing strategic planning, not a strategic plan.

Strategic planning is more than filling out forms, or compiling a document. Most of the value of strategic planning is realized during the process of planning itself.
**Recommended Strategic Planning Process**

- Situation Inventory/Environmental Scan
- Customer Analysis
- Quality Assessment and Benchmarking
- Strategic Issues

**Where Are We Now?**

- Broad, comprehensive statement of the agency's purpose
- Core values, actions to achieve mission
- Employee and Management involved

**Where Do We Want To Be?**

- When combined with mission & principles, identifies agency's uniqueness
- Compelling image of desired future

**How Do We Get There?**

- The desired result after 3 or more years
- Specific and measurable targets for accomplishment
- Leads to Quality Initiative goals and objectives

**How Do We Measure Our Progress?**

- Strategies used to accomplish goals and objectives
- Detailed work plans
- Leads to resource allocation

- Methods used to measure results
- Ensures accountability and continuous improvement-linked performance targets

- Systems to monitor progress
- Compiles management information
- Keeps plan on track

Source: State of Arizona’s Strategic Planning and Performance Management Handbook, “Managing for Results”

**Note:** In practice the process is not linear; some steps may be repeated as assumptions change.
◆ Prior to Developing the Plan

Several steps are normally taken prior to addressing and developing the “Where Are We Now?” part of the plan, including: (a) conducting a readiness assessment, (b) agreeing on a strategic planning process, and (c) forming strategic planning teams.

Developing a strategic plan for an entire agency requires formation of a planning team composed of senior executives and involves a broad spectrum of department staff in various phases of the planning process.

◆ Participants in the Strategic Planning Process

Strategic planning is a team effort. It involves all levels and functional units of an agency—top executives, middle managers and supervisors, and employees. Although strategic planning begins at the top, leaders should seek and reflect the input of managers, supervisors, and front-line employees who may know their customers and services best.

The size of the team will vary with the size and complexity of the agency. In a large agency, all of the participants listed below may be involved.

Depending on the size of the agency, successful strategic planning may include the following team participants:

**Director**, who provides the leadership necessary to define the mission, craft the vision, and express the principles of the agency. The director must lead and actively support the planning process.

**Members of Boards/Commissions** play an important policy-making role in the planning process. Boards and Commissions can assist in developing the mission, principles, and vision of the agency. They can also provide valuable feedback during the planning process.

**Executive Management Team**, consisting of the agency’s top management and other staff, use their knowledge of services and functional areas to: (1) work with the director in defining the agency’s mission, expressing the agency’s principles, and crafting an agency-wide vision; (2) set goals to provide direction for the whole agency and to address identified issues, problems, and opportunities; and (3) monitor overall progress and results. (In some agencies, senior executives may set objectives and strategies as well.) The team should include knowledgeable individuals from all programs or services operated by the agency, yet not become so large as to be cumbersome. Many agencies already have executive management teams that routinely meet and handle management issues.

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**Key Point**

Some leaders will be tempted to pay lip service to strategic planning while shunning actual involvement in the process; others will be tempted to prepare the whole plan on their own. Leaders must recognize their own role in the plan as well as the roles of others in the agency. The executive who wholly delegates his or her responsibility sends the message that strategic planning is not important enough to warrant his or her involvement. The executive who puts together a plan without participation from the managers and staff who must actually carry out the plan produces a document to which only one person—that executive—is committed.
group may serve as the nucleus of the planning team, along with additional resource persons who can contribute because of their knowledge, regardless of their rank in the agency.

**Quality Councils**, if established, can ensure coordination of the strategic planning process with the agency’s quality improvement efforts.

**Middle Managers, Program Managers, Supervisors, and Front-line Employees**, who have direct program involvement and can carry the planning process into the program level—defining program missions and principles, setting program goals and specific objectives, developing courses of action or strategies to achieve objectives, operationalizing strategies through action plans, establishing and maintaining performance measures, and determining needed resources.

**Financial or Budget Managers**, who must analyze fiscal impacts of potential strategies, provide technical support, and use strategic plans to guide development of annual operating budgets and capital outlay budgets.

**Facility Managers**, who must analyze the impacts of implementing potential strategies on the agency’s physical facilities and use strategic plans to guide development of capital outlay plans and budgets.

**Human Resource Managers**, who must analyze the impacts of implementing potential strategies on the agency’s workforce, training programs, and human resource management policies.

**Information Technology Systems Managers**, who must analyze the impacts of implementing potential strategies on the agency’s information technology management systems.

**Strategic Planner or Planning Coordinator**, who provides the coordination and tools for moving the organization through the planning process. The strategic planner or planning coordinator develops the timetable and organizes the entire process. (“Strategic Planner” or “Planning Coordinator” can be a functional title, not a position. A large agency may have more than one planner. In a small agency, the director may be the planning coordinator.)

**Total Quality Management (TQM) Coordinator**, who is responsible for coordinating the agency’s quality improvement effort, if established. Involvement of the TQM coordinator can ensure that the agency’s strategic planning and total quality efforts will be integrated. (“TQM Coordinator” may be a functional title, not a position.)

**Facilitator**, who can help guide participants through planning sessions, by assuring that all views are considered. A facilitator is a
neutral party who is sometimes used to keep the discussion flowing. ("Facilitator" is a functional title, not a position, and may be someone from outside the agency.)

**COMPONENTS OF A STRATEGIC PLAN**

Strategic planning asks and answers four basic questions. The process of addressing these questions produces responses which become the Strategic Plan. The components of a recommended strategic planning process that correspond with these questions are as follows:

**WHERE ARE WE NOW?** Before an agency can develop a plan for a change, it must first determine where it currently stands and what opportunities for change exist. Strategic planning is supported by:

**External/Internal Assessment.** An analysis and evaluation of key internal and key external data and factors that influence the success of an agency in achieving its mission and goals. Two components of this assessment are:

- **Situation Inventory.** An assessment of an agency’s position, performance, problems, and potential; in other words, its strengths and weaknesses.

- **Environmental Scan.** An analysis of key external elements or forces, including the stakeholder analysis, that affect the environment in which an agency functions. This is commonly referred to as the opportunities of and threats to the agency.

In developing a strategic plan, an agency should consult with the Legislature and solicit and consider the views and suggestions of entities, such as customers and other stakeholders, potentially affected by or interested in the plan.

**Mission.** The agency’s unique reason for existence; the overarching goal for the agency’s existence, usually contained within a formal statement of purpose. In addition, mission statements can be developed at the program and subprogram level.

**Principles.** The agency’s core values and philosophies describing how the agency conducts itself in carrying out its mission.

**WHERE DO WE WANT TO BE?** Strategic planning identifies:

**Vision.** A compelling, conceptual, vivid image of the desired future.

**Goals.** The desired end result, generally after three or more years.

**SMALL AGENCY HELPFUL HINT**

Obviously, a small agency, compared to a large agency, will not have as many people on the planning team. Often one person performs the work of several of the suggested participants. For instance, the Executive Director may also be responsible for the budget, information technology, personnel, and planning. In such cases, a small agency may choose to include any other key staff members on the planning team. Board and Commission members can also play an important role in the planning process.
Objectives. Specific and measurable targets for accomplishment of a goal.

**How Do We Get There?** Strategic planning develops:

- **Action Plan.** A detailed description of the key strategies used to implement each objective.

**How Do We Measure Our Progress?** Strategic planning builds in:

- **Performance Measures.** The methods used to measure results and ensure accountability.

- **Monitoring and Tracking Systems.** The systems to monitor progress, compile management information and keep the plan on track.

Finally, strategic planning guides:

- **Resource Allocation.** The determination and allotment of assets or resources, including those for capital outlay, necessary to carry out strategies and achieve objectives, within a priority framework.

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**Applying the Strategic Planning Process**

There is not a fixed “cookie-cutter” process that can be used for every agency. Agencies should tailor the strategic planning process to their management needs and agency and program structures. The process is not linear. Sometimes the results of one step may cause the team to go back to a previous step because assumptions have changed.

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**Communicating and Marketing the Plan**

Successful implementation of the strategic plan depends on effective communication:

Internally, the strategic plan should be communicated to all organizational levels. Managers and staff need to have a clear understanding of the plan and their roles in it. A “perfect” plan has little value if it is not widely understood and accepted. It must form the basis for daily action throughout the agency. Some ideas for improving internal communications about the plan include:

- Talk about the plan at staff meetings.
- Write articles about the plan for internal newsletters.
- Distribute copies of the full plan to program managers.
- Prepare a condensed brochure version of the plan to share with all employees.
Display the mission statement in a prominent location in the building.

Recognize progress on achieving the plan's goals and objectives at staff meetings, in newsletters, and at other agency events. Celebrate accomplishments.

Externally, the strategic plan should be communicated to individuals and organizations that have an interest in, or an effect on, the agency's programs (e.g., the Governor, Legislature, local governments, interest groups and the public). Various marketing approaches have been used to communicate information about the plan to those outside the agency to help build awareness of and support for the plan. Eye-catching visual presentations are especially effective. Large agencies may have public information offices who help develop marketing strategies. However, small agencies can accomplish the same purposes by utilizing some of the following ideas:

- Put the mission statement on letterhead and business cards.
- Include articles about the plan in agency newsletters.
- Explain the plan at community public meetings.
- Issue press releases with highlights concerning the plan.
- Prepare a condensed version of the plan in an attractive brochure and distribute it to interested persons and organizations.
- Reference the plan in speeches to the Legislature, private sector and community groups.
- Provide media interviews.
- Give presentations at conferences ("dog and pony shows").
- Produce a video or special newsletter on the strategic plan.

◆ TIMING

Forecasting and Planning Horizon—Where We Should Be Going. Currently, the planning horizon of most plans is five years or less. This is inherently insufficient in establishing agency planning objectives and strategies to direct growth and to address long-term impacts. Strategies needed to address long-term impacts by their very nature require analyses that goes beyond a mere five years.

In general, agencies responsible for physical infrastructure management and expansion (such as the Department of Transportation and the Department of Water Resources) plan for the long term, while agencies responsible for program administration (such as the Department of Aging and the Office of Statewide Health Planning and Development) plan for short-term program
implementation. Most agencies in State government react to growth rather than influence or direct it, as indicated by their short planning time frames (1 to 5 years) and by their lack of specific strategies and actions addressing long-term growth issues.

Most agencies should prepare long-term strategies to meet and direct anticipated demand for services and facilities within their jurisdiction.

Long-term strategic planning can serve as a tool in growth management by identifying growth issues impacting the agency, identifying funding needs and determining least cost alternatives, establishing early coordination with other agency plans and developing strategies to direct this growth.

Some strategic plans span too short a time period. This precludes effective measurement of results, since impacts upon an agency beyond a five-year period cannot be considered, including any significant demographic changes occurring in the population served by the agency. A long-term strategic plan that addresses the needs of an agency's client population, and identified strategies on how to accommodate the increasing or decreasing population would help the agency prepare for future program requirements, as well as facilitate integration of related growth issues.

**No Initial Minimum Time Frame.** There is not a specified minimum time frame for agency strategic plans. However, a long-term strategic plan that addresses future program growth for the five-to-ten-year period will have greater control of its destiny.

**Annual Survey.** Annually, the DOF surveys each agency, department, office, and commission to determine which entities have, or have not, completed strategic plans, and the dates on which those plans were completed or last revised. The DOF is then required by statute to submit to the Governor and to the Joint Legislative Budget Committee the results of the survey and to identify those agencies for which the DOF recommends the development or updating of a strategic plan. (Appendix E, reference #7).

On April 30, 1996, the DOF made its recommendation to the Governor and to the Joint Legislative Budget Committee. Its recommendation was the development of a Strategic Plan by all state entities.

**Annual April 1 Report Due from Agencies Not Now Having a Plan.** As a result of this recommendation, Government Code Section 11816, Chapter 779, Statutes of 1994 becomes operative. This section adds the following requirement for agencies not identified in the 1996 survey as having a plan:

> “Each agency, department, office, or commission shall develop a strategic plan and shall report to the Governor and to the Joint Legislative Budget Committee by April 1, 1995 and by each April 1 thereafter on the steps being taken to develop and adopt a strategic plan. This report shall include a description of the elements to be
included in the strategic plan, the process for developing and adopting the strategic plan, and a timetable for the plan's completion. In developing its strategic plan, each agency, department, office, or commission shall consult with at least the following affected parties: employee organizations, the Legislature, client groups served, suppliers, and contractors. The report shall also identify the steps being taken to develop performance measures that could be used for a performance budgeting system or a performance review.”

**Note**

On August 9, 1996, the DOF issued Management Memo 96-23, Strategic Planning Requirements. Management Memo 96-23 requires that all state organizations have a strategic plan completed and approved by July 1, 1997. The Memo identifies the minimum components of a strategic plan, and states that the plans will be the basis for subsequent budgetary actions.

**Relationship to the Budget Process.** Because the strategic plan should drive an agency’s budget, it should be developed or updated preceding the budget process, including that for capital outlay. Once the strategic plan is developed, it should be continually monitored and updated. Strategic planning continues to be a dynamic, ongoing process. Budget Letters 96-08, 96-16, 96-23, 97-07 and 98-07 also addresses Strategic Planning Requirements.

**Revisions.** Significant changes to a strategic plan should be made through a revision of the strategic plan. All strategic plan revisions must be approved by the Governor’s Office. All departments that report to an Agency Secretary must obtain the Agency Secretary’s approval of the department’s strategic plan revisions. After the Agency Secretary approves the revision(s), the Agency Secretary will transmit the revision(s) to the Governor’s Office (addressed to the appropriate Deputy Cabinet Secretary) for Governor’s Office approval.

Departments that do not report to an Agency Secretary must have the approval of its Department Director or Executive Officer and then transmit the revision(s) to the appropriate Program Budget Manager in the Department of Finance for review. After the Program Budget Manager reviews the revision(s), it will be transmitted to the Governor’s Office for approval.

Approval of a strategic plan revision does not indicate budgetary approval or approval of any budget change proposals relating to the revision.

The department shall provide to the Office of State Audits and Evaluations three copies of its plan approved by the Governor’s Office.

**Funding for the Planning Process.** No additional funds will be provided to agencies for strategic planning. Resources to undertake the strategic planning process are to come out of an agency’s existing resources. Strategic planning is an inherent function of management that is already funded in agency resources.
### STRATEGIC PLANNING CALENDAR

#### Fiscal Year 1996-97

<table>
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<tr>
<th>Month</th>
<th>Activity</th>
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<tr>
<td>January - February 1997</td>
<td>DOF conducts 1997 (annual) strategic plan survey</td>
</tr>
<tr>
<td>March 1997</td>
<td>DOF issues survey report and makes recommendations</td>
</tr>
<tr>
<td>April 1, 1997</td>
<td>Annual report due to the Governor and JLBC from each agency department, office, or commission not having a strategic plan for the 1996 strategic plan survey</td>
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#### Fiscal Year 1997-98

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<th>Month</th>
<th>Activity</th>
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</thead>
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<td>All agencies required to have an approved strategic plan</td>
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<tr>
<td>Fall 1997</td>
<td>Fiscal Year 1998-99 Budget Change Proposals prepared based on an approved strategic plan</td>
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<tr>
<td>January - February 1998</td>
<td>DOF conducts 1998 (annual) strategic plan survey</td>
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<tr>
<td>April 1, 1998</td>
<td>Annual report due to the Governor and JLBC from each agency department, office, or commission not having a strategic plan for the 1996 or 1997 strategic plan surveys</td>
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<tr>
<td>May 1998</td>
<td>DOF issues survey report and makes recommendations</td>
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#### Fiscal Year 1998-99

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<td>All agencies required to submit strategic planning information to the Governor’s office for approval</td>
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<tr>
<td>Fall 1998</td>
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Reference: Government Code Section 11816. “Each agency, department, office, or commission for which strategic planning efforts are recommended pursuant to Section 11813 shall develop a strategic plan and shall report to the Governor and to the Joint Legislative Budget Committee by April 1, 1995 and by each April 1 thereafter on the steps begin taken to develop and adopt a strategic plan. This report shall include a description of the elements to be included in the strategic plan, the process for developing and adopting the strategic plan, and a timetable for the plan’s completion. In developing its strategic plan each agency, department, office, or commission shall consult with at least the following affected parties: employee organizations, the Legislature, client groups served, suppliers, and contractors. The report shall also identify the steps being taken to develop performance measures that could be used for a performance budgeting system or a performance review.”
APPENDICES

Appendix A: Glossary of Selected Planning and Budgeting Terms
Appendix B: Basic Process for Agency Strategic Planning
Appendix C: Instructions for 1998 Submittal of Strategic Planning Information
Appendix D: Help for the Planning Process
Appendix E: References
APPENDIX A

GLOSSARY OF SELECTED PLANNING AND BUDGETING TERMS

**Action Plan** is a detailed description of the strategies used to implement an objective. Action plans break strategies into manageable parts for coordinated implementation of goals and objectives. Task specification includes staff assignments, material resource allocations, and schedules for completion. Action plans specify detailed cost and expenditure information and are often referred to as “operational plans” or “implementation plans.”

**Agency.** Each of the various state government organizations that provides goods and services. For the purpose of this booklet, the term refers to any state organizational unit of the executive branch of State government including agencies, departments, boards, commissions, and offices. Such a State agency is created by statute or constitutional provision with statewide jurisdiction. It possesses administrative authority and resources independently of another State agency. Excluded by statute from the provisions of Chapter 779 are the Bureau of State Audits, the California State Lottery Commission, and the University of California.

**Benchmark** is a standard or point of reference in judging quality, cost-effectiveness or performance.

**Benchmarking** is the process of rating an agency’s practices, processes, and products against the best and then emulating them. It involves seeking out best-in-class performers inside or outside the agency, studying them to determine why they are the best at what they do, and applying what is learned.

**Cost-benefit Analysis** is a management tool that involves calculating or estimating the known costs and potential benefits of a course of action under consideration.

**Customers** are people, internal or external to the organization, who receive or use what an agency produces. Customers are also anyone whose best interests are served by the actions of the agency. Customers can also be clients.

**DOF.** The California State Department of Finance.

**Efficiency Measures** are indicators of the input resources required to produce a given level of output (good or service). It is a measure of resource cost in dollars, employee time, or equipment used per unit of product or service output. An efficiency measure relates agency efforts to agency outputs. Indicators of average cost and average time normally serve as efficiency measures for agency processes, but they may also serve as
outcome measures when cost-per-unit-of-outcome is the focus and can be meaningfully captured. The act of providing the highest quality goods or services at an established cost. Efficiency measures are also known as productivity measures.

**Environmental Scan** is an analysis of key external elements or forces that influence the conditions in which an agency functions. This is commonly referred to as the opportunities and threats to the agency.

**External Variables** are factors not controlled through the policy or program that may have independent and significant effects on outcomes such as economic downturns, population shifts, technological advances, cultural differences or changes.

**Facilitator** is someone who keeps the discussion flowing in planning sessions. A facilitator does not express an opinion, but helps ensure that the views of all participants are considered in the discussion.

**Goals** are the desired end result, generally after three or more years.

**Agency goals** are the general ends toward which agencies direct their efforts. A goal addresses issues by stating policy intention. They are both qualitative and quantifiable, but not usually quantified. In a strategic planning system, goals are ranked for priority. Goals stretch and challenge an agency, but they are realistic and achievable.

**Functional goals** are the general ends toward which the State directs its efforts. Functional goals address the primary issues facing the State within broad groupings of interrelated State concerns. Functional goals are founded on the statewide vision and may involve coordination among several agencies with similar functions.

**Input Measures** are tools, or indicators, which identify the amount of resources needed to provide a particular product or service. Inputs include labor, materials, equipment and supplies.

**Internal/External Assessment** is the analysis and evaluation of key internal and key external data and factors that influence the success of an agency in achieving its mission and goals. Detailed evaluation of trends, conditions, opportunities, and obstacles directs the development of each element of the strategic plan. This type of assessment should be heavily quantitative. Key internal factors include management policies, resource constraints, organizational structure, automation, personnel, and operational procedures. Key external factors may include economic conditions, population shifts, technological advances, geographical changes and/or statutory changes.

**JLBC.** The California State Legislature’s Joint Legislative Budget Committee.
**Measurement** is a quantitative assessment of performance, quality or cost used to guide policy and the decision-making process. Measurements help guide staff and define objectives.

**Mission** is the agency’s unique reason for existence; the overarching goal for the agency’s existence, usually contained within a formal statement of purpose. It succinctly identifies what an agency, program or subprogram does (or should do) and why and for whom it does it. The statutory mission statement is usually found in the legislation creating the agency. A mission statement reminds everyone—the public, the Governor, legislators, the courts, and agency personnel—of the unique purposes promoted and served by the agency.

**Monitoring and Tracking Systems.** The systems to monitor progress, compile management information and keep the plan on track.

**Objectives** are specific and measurable targets for accomplishment of a goal. They mark interim steps toward achieving an agency’s long-term mission and goals. Linked directly to agency goals, objectives are measurable, time-based statements of intent. They emphasize the results of agency actions at the end of a specific time.

**Outcome Measures** are indicators of the actual impact or effect upon a stated condition or problem. These measures address whether or not the service is meeting its proposed goals. They are tools to assess the effectiveness of an agency’s performance and the public benefit derived.

“True outcome measures are likely to report performance in terms of changed public or client behavior. Although outcome measures are generally preferable to efficiency or output measures, since they are most relevant to whether intended public policy goals are met, they sometimes suffer from a lack of proximate linkage to the responsibilities of the administering department. The outcome of enhanced public safety for a program’s clientele, for example, could be affected by broader societal variables (e.g., the economy, criminal sentencing policies) as well as a program’s crime prevention and law enforcement efforts. Thus, in some cases, a program’s reported performance may not be exclusively controlled by the administering department and the investment level appropriated for that outcome. Accordingly … departments should review the causal linkages between all outcome oriented performance measures and their own responsibilities … department should attempt to control and/or clearly explain the effects of any extraneous variables, including the articulation of any assumptions with respect to such effects. While every effort should be made to establish outcome measures with strong causal linkages to program responsibilities, the departments may sometimes have to settle for output or efficiency measures if they cannot control or explain the effects of external influences.
“In contrast, output or efficiency indicators are usually under the control of an administering department” (Appendix E, reference #1, page 16).

**Output Measures** are tools, or indicators, which represent the amount of products or services provided by an agency. The number of people receiving a service or the number of services delivered are often used as measures of output.

**Performance Accountability** is a means of judging policies and programs by measuring their progress toward achieving agreed-upon performance targets. Performance accountability systems are composed of three components—defining performance measures including outcomes, measuring performance, and reporting results.

**Performance Budgeting** allocates resources based on an expectation of performance levels, where performance is measured in specific, meaningful terms. It focuses on outcomes, rather than inputs or processes, in deciding how to allocate resources … (Appendix E, reference #1, page 1).

A Performance Budgeting Pilot Project (Pilot Project) was announced in the January 1993 Governor’s Budget and subsequently approved by the Legislature in the Performance and Results Act (SB 500 [Chapter 641, Statutes of 1993]). The Performance and Results Act (Act) requires the Department of Finance to evaluate the Pilot Project and report to the Chairperson of the Joint Legislative Budget Committee. In particular, the Act requires the evaluation to include attention to “… the extent to which performance budgeting results in a more cost-effective and innovative provision of government services … [and the] gainsharing rewards to each department in the … [project as well as] the specific innovation which brought about the savings.”

Performance budgeting appropriates funding in anticipation of realizing agreed upon levels of performance. Accordingly, it is important to allocate budgeted dollars for specific levels of targeted performance. To the extent feasible, these performance levels should be framed in terms of program outcomes. (Appendix E, reference #1, page 9).

Performance budgeting should involve: (a) the development of quantifiable performance measures which serve as indicators or proxies for program outcomes, outputs or efficiency; … (Appendix E, reference #1, page 6).

**Performance Measures.** The performance measure is a management tool that measures work performed and results achieved. It describes (a) what is to be measured, and (b) the methods of measurement. The measure may be short- intermediate- and/or long-term.
Principles. Principles are human factors which drive the conduct of an agency and function as a guide to the development and implementation of all policies and actions. Often an agency's principles are implicitly understood, but it can be helpful to explicitly state them. Principles summarize the operating philosophies or core values that will be utilized in fulfillment of the vision and mission. Thus, principles are the bridge between where we are and where we want to be.

Program Performance. The Department of Finance believes that measurement of program performance should be a function of a program's legislated purposes. Depending on the specific purposes, a program's public outcomes or impacts (or indicators thereof) may be more or less susceptible to precise quantification. When program outcomes cannot be precisely quantified, performance might be best evaluated through measurement of efficiency or output indicators, coupled with ad hoc qualitative evaluations of effectiveness in achieving program purposes. In either case, however, the program measurements or indices (whether of efficiency, outputs or outcomes) should be relatively consistent from year-to-year, to allow longitudinal comparison of performance levels. (Appendix E, reference #1, page 6).

Quality measures are indicators which reflect the effectiveness in meeting the expectations of customers and stakeholders. Measures of quality include reliability, accuracy, courtesy, competence, responsiveness, and completeness associated with the product or service provided.

Resource Allocation. The determination and allotment of resources or assets necessary to carry out strategies and achieve objectives, within a priority framework.

SAM. California State Administrative Manual.

Situation Inventory is the internal assessment of an agency's position, performance, problems, and potential; in other words, its strengths and weaknesses.

Stakeholders are groups or individuals that have a vested interest or expect certain levels of performance or compliance from the agency. Stakeholders do not necessarily use the products or receive the services of a program. Sometimes referred to as expectation groups.

Strategic Issues are those concerns of vital importance to the organization. Often they impact several or all of the programs in an agency. Identifying these few critical concerns can help an agency focus on high priority goals for the agency as a whole.

Strategic Plan. A practical, action-oriented guide, based upon an examination of internal and external factors, which directs goal-setting and resource allocation to achieve meaningful results over time.
Strategic Planning is a long-term, future-oriented process of assessment, goal-setting, and strategy building that maps an explicit path between the present and a vision of the future, that relies on careful consideration of an organization’s capabilities and environment, and leads to priority-based resource allocation and other decisions. It includes the process of developing a strategic plan. Because strategic planning is a team effort that builds consensus on a future direction for an agency, the process itself is more important than the resulting document.

Strategies are methods to achieve goals and objectives. Formulated from vision and mission, a strategy is the means for transforming inputs into outputs, and ultimately outcomes, with the best use of resources. A strategy reflects budgetary and other resources.

Tracking and Monitoring Systems are systems that monitor and report progress on implementing goals and objectives.

Vision is a compelling, conceptual, vivid image of the desired future. A vision focuses and ennobles an idea about a future state of being in such a way as to excite and compel an agency toward its attainment. It crystallizes what management wants the organization to be in the future. A vision is not bound by time, represents global and continuing services, and serves as a foundation for a system of strategic planning.
APPENDIX B

BASIC PROCESS FOR
AGENCY STRATEGIC PLANNING

Step 1: The agency conducts an internal/external assessment (with input from various levels of the agency and external stakeholders.)

Step 2: The agency director and planning team define the agency mission and express the agency's principles.

Step 3: The agency director articulates a vision for the agency. This vision is communicated to every level of the agency and shared by everyone in the agency.

Step 4: The director and planning team establish agency goals and objectives for the agency as a whole, based on consideration of external factors and internal capacities (revealed in the internal/external assessment.)

Step 5: The director and planning team identify performance measures for the agency goals and objectives and set performance targets.

The Governor's Office of Planning and Research (OPR) should also be involved at this state to coordinate the review of the agency's strategic issues by other State agencies. This will ensure that agencies are not working at cross purposes or in ignorance of the activities of other arms of the State. Where conflicts are identified, OPR should mediate solutions if the affected agencies cannot come to an agreement.

Step 6: The director and planning team in the agency communicate the agency mission, principles, goals and objectives to every level of the agency. Action plans are then developed to implement the agency strategic plan.

Step 7: Program managers and their key staff members define program and subprogram missions and establish program and subprogram goals (based on internal/external assessment, including a consideration of resources needed for achievement) that are consistent with agency mission, principles, and goals.

Step 8: Program managers, strategic planners and key staff members (including budget managers and key fiscal staff, facility managers, human resource managers, information systems managers, and
front-line supervisors) develop measurable program and subpro-
gram objectives, build strategies, and identify resources necessary
to implement strategies and accomplish objectives. Intermediate
performance measure targets should be established for each
objective that represents incremental improvement. However,
objectives, strategies and performance targets should be consid-
ered “tentative” or “proposed” until input is received from the
front-line personnel who will bear the responsibility for carrying
out strategic objectives and implementing them through action plans.

Step 9: Program managers and key staff members develop a balanced set
of significant performance measures for each program and
subprogram goal and objectives and set performance targets.

Step 10: Feedback and rollup begin. Within each program, subprogram
plans are submitted to the next higher management level for
review and coordination. After revisions (if any) are made, the
approved elements are incorporated in the appropriate portion
of the program strategic plan. During feedback and rollup it may
be necessary to revise objectives or strategies originally proposed.

For example, Input for front-line levels may show that the
time-frame or resource allocation originally projected for a
particular strategy should be changed.

As strategies are “fleshed-out,” it may become apparent that the
time-frame or degree of change proposed in an objective should
be altered. Performance measures may be aggregated in the
move to higher levels.

Step 11: Program managers combine all subprogram elements into a
program strategic plan and submit this plan, through the
planning coordinator, to the agency director and the planning
team for review and coordination.

Step 12: The agency director and planning team review any subprogram
plans. They identify opportunities for coordination among
program plans; they pinpoint the efforts they must make to
support program plans and break down barriers to accomplish-
ing objectives. They may also modify the plan for the agency as a
whole based upon the program plans.

Step 13: The entire organization puts the agency, program and subpro-
gram strategic plans into action and uses a tracking and
monitoring system to measure progress. The plan guides
both operational planning and budgeting and capital outlay
planning and budgeting. Strategic plans and performance results
are regularly evaluated, and the plan is revised accordingly.
Successes are celebrated and rewarded; lack of progress is
analyzed, lessons are learned, and appropriate changes made.
APPENDIX C

Instructions for 1998 Submittal of Strategic Planning Information

By July 1, 1998, each agency is required to submit strategic planning information to the Governor’s Office for approval. Submittal of this information may take one of two forms: (1) a letter from the department director attesting to no changes to the previously approved strategic plan, or (2) a revised strategic plan.

Agency Attestation Letters

The attestation letter must specify that there are no changes to the agency’s previously approved strategic plan. For the purposes of this letter, ‘no changes’ means that there are no changes to the goals or objectives contained within the approved plan. The dated letter is to be signed by the head of the agency.

Agency Strategic Plans

Budget Letter 98-08 identifies a new requirement: each agency must revise its approved strategic plan if there is 1) a change in any goal, or 2) a change in any objective, or 3) a proposed budget request that will not tie into the existing plan. (All agencies are assumed to have a strategic plan, since Management Memo 96-23 requires that each agency develop a strategic plan by July 1, 1997.)

The agency strategic plan establishes and documents the future direction for the agency as a whole. The agency strategic plan reflects a “top-down” orientation that transcends the agency’s program structure. Through the agency strategic plan, the director can articulate priorities for the entire agency over a minimum of the next three years.

The agency strategic plan is based upon identification of important issues that impact the agency. These strategic issues are clarified during the process of conducting the agency’s internal/external assessment. Strategic issues may be a combination of many different operational or programmatic concerns.

For example, issues affecting multiple programs, system-wide operational issues (e.g., information systems, or personnel management), agency public relations/customer concerns, or resource issues.

1 The term “agency” is used to refer to a State Agency, department, board, commission, or office.
Agency strategic issues can also result from statewide policy issues that have been identified through Executive or Legislative initiatives. In addition, strategic issues may be cross-functional and involve other agencies or organizations.

Although an agency may choose to have a strategic planning process addressing all future actions, only the key future action items are to be documented in the strategic plan that is sent to the Governor's Office. Typically, the director and executive management team should and will select only a few strategic issues to address in the strategic plan which is to be approved by the Governor's Office. In this way, they remain focused on the most important concerns. Goals, objectives, performance measures, and action plans are then developed in response to the agency's strategic issues.

**GENERAL GUIDELINES FOR AGENCY STRATEGIC PLAN SUBMISSIONS**

While agencies have considerable latitude in preparing their plans, they are requested to arrange their information according to a standard table of contents. This will maintain a degree of continuity between different agency documents and ensure compliance with the minimum requirements. The suggested Table of Contents for the plan is shown below. Components recommended, but not required, are so noted. The Table of Contents is revised for the 1998 submittals.

### STRATEGIC PLAN SURVEY AND REPORTING TO THE LEGISLATURE

Government Code Title 2, Division 3, Part 1, Chapter 8.1 (commencing with Section 11810) sets forth the State Government Strategic Planning and Performance Review Act. Among other things, it requires the Department of Finance (DOF) to 1) conduct surveys to determine the status of strategic plans, 2) identify agencies for which DOF recommends the development or updating of a strategic plan, and 3) develop a plan for conducting performance reviews of all agencies.

The 1998 survey forms were sent to agencies for which the DOF Office of State Audits and Evaluations had no record of a current approved strategic plan.

Beginning with the issuance of Budget Letter 96-16, the Department of Finance, pursuant to Government Code Section 11815, continues to require all agencies to develop or update a strategic plan.

If an agency does not have an approved strategic plan, a requirement is placed on it by the Legislature and described in Government Code Section 11816. By April 1 of each year, that agency is required to annually submit to the Governor and to the Joint Legislative Budget Committee the report described in Section 11816. This report is in addition to the requirements included in any Budget Letter or Management Memo.
SCOPE OF THE STRATEGIC PLAN

The plan should be oriented toward the vital few strategic goals that reflect key future direction for the organization as a whole. This documentation of the agency strategic planning process is not intended to be a recompilation of every program and subprogram goal or objective.

An agency should consider the prospective readership of its strategic plan when determining length, style, and understandability. The presentation and effort should be commensurate with the size and complexity of the agency.

Brevity and conciseness will likely characterize plans that are useful and widely read. One way to achieve this is to keep the number of goals to a manageable level.

STRATEGIC PLAN FORMAT

What is the format of a Strategic Plan? There is no prescribed detailed standard format. Except for the guidelines below, each agency may determine the format and content of the documentation of its strategic plan. The documentation must satisfy agency management requirements and be sufficiently detailed to provide the Governor’s Office, the Agency Secretary (as appropriate), the DOF, and other stakeholders with a clear understanding of the agency’s strategies. It is the responsibility of the agency to ensure that the information available to the Governor’s Office, the Agency Secretary (as appropriate), and the DOF represents its current strategy.

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* recommended components but not required
**Agency Strategic Plan Components**

Each component in the strategic plan table of contents is summarized below.

- **Executive Summary**—This should encapsulate:
  
  1. what the agency hopes to achieve with this plan;
  2. a brief description of the plan’s context; its purpose and scope (i.e., what it is intended to do), its relationship to other state plans and state planning goals, its relationship to the state budget, and when it will be revised;
  3. the key elements of this strategic plan; and
  4. the name and the phone number of the agency’s contact persons who will respond to
     
     a) questions about the plan, and
     
     b) requests for copies of the plan.

- **Table of Contents**—the Table of Contents given above is the basic table for 1998.

- **Agency Mission Statement**—the reason for the agency’s existence.

- **Agency Description**—a summary of the agency’s major duties, responsibilities and customers served. This information will provide the reader with more background information about the agency. If the agency intends to widely distribute the plan, this additional information becomes more valuable.

- **Agency Principles**—the agency’s core principles.

- **Agency Internal/External Assessment Summary**—an evaluation of key factors which influence the success of the agency in achieving its mission and goals. At a minimum, the agency should provide a brief summary of the key external opportunities and threats, as well as strategic issues, that have been identified during the internal/external assessment. (Internal strengths and weaknesses, while identified during the assessment, do not need to be reported.) Agencies may also choose to include tables, charts, and graphs to illustrate information that supports the internal/external assessment. Graphics can be incorporated in the text, or provided in the Appendix. In their sections on Internal/External Assessment, agencies may also want to summarize their general planning assumptions. However, resource assumptions are to be addressed separately, as discussed below.
Agency Vision—the agency’s image of the desired future.

Agency Goals—the desired end result, generally after three or more years. Agency goals should reflect the most important strategic issues for the organization as a whole; they should not represent a comprehensive inventory of every program activity. Generally, since the goals in this document only represent key goals, five or fewer strategic goals will be sufficient for most agencies.

Agency Objectives—clear targets for specific action to fulfill the agency’s strategic goals. An agency may have multiple objectives under a single goal; however, at a minimum, each stated goal must have at least one objective for each of the following three fiscal years: 1998-99, 1999-2000, and 2000-01.

(Budget requests must provide the cross-reference to the specific objectives in an organization’s strategic plan. Therefore, the cross-reference should not appear in the strategic plan. The strategic plan is not a wish list of budget requests.)

Agency Performance Measures—the quantified results to be achieved. Performance measures provide a basis for assessing successful achievement of the agency mission, vision, goals, and objectives by focusing on attainment of the objectives. However, in order to retain focus on only the most significant, the vital few, the agency should limit the number of measures by selecting only the most pertinent measures for each objective for which data can be collected. (More than three or four measures will probably be too many.) At a minimum, there should be at least one key performance measure under each objective.

When considered in the aggregate, agencies should strive for a balance of measures in their strategic plans, with an emphasis on outcome, efficiency, and quality measures. The use of simple input and output measures is not encouraged.

At a minimum, actual and projected performance data, for the 1998 submittal, should be shown for the following fiscal years:

- FY 1995-96 actual
- FY 1996-97 actual
- FY 1997-98 estimated (target)
- FY 1998-99 expected (target)
- FY 1999-2000 expected (budget year target)
- FY 2000-01 expected (target)

Two actual years show the established base level.
The current year is shown (FY 1997-98). The next three years show the agency objectives in the strategic plan.
Resource Assumptions—assumptions about resources required to implement the agency strategic plan. In this section, an agency should indicate whether they can accomplish the agency goals, annual objectives and performance targets within their existing budget or with reduced resources, or if additional resources must be requested. Keeping in mind that the strategic plan is not a budget document, the intent of this section on Resource Assumptions is to provide brief statements that strengthen the link between the plan and the budget. Resource assumptions for both appropriated and non-appropriated funds should be noted.

For fiscal year 1997-98 estimates, agencies should develop their goals, objectives and performance targets based on their fiscal year 1997-98 appropriation and other expected funds. A general statement to this effect should be included in the Resource Assumption section. Any exceptions are to be explained, and the affected goal, objective or performance target designated by an appropriate footnote.

Agencies should also describe their resource assumptions for fiscal year 1998-99 and subsequent fiscal years. If they can accomplish their agency goals, objectives and performance targets within their current base budget, they should add a general statement to indicate that no new resources are being sought to support the agency strategic plan. Agencies may find it helpful to explain that they intend to achieve their planned results in fiscal year 1998-99, and subsequent specifically identified fiscal years, by other means such as by improving a process or reallocating existing resources.

Appendix Items

A. Required:

Methodology Statement—a brief description of the internal planning process used and the participants involved in the development of the strategic plan. It should address the stakeholder involvement to date in building the plan’s (a) vision, (b) goals, and (c) objectives. It can include a brief description of how the plan was put together: identification of participants, in what kinds of forums, and a list of references and/or organizations involved in the development of the plan. It can include a description of the method by which planning actions are prioritized.

B. Optional, and provided at the agency’s discretion

Agency Action Plans—the methods or strategies used to accomplish objectives and the summary of the detailed descriptions of how strategies will be implemented on an operational basis.
Agency Organization Chart—the current Organization Chart which displays the division and subdivisions within the agency and lines of authority. For large agencies, a summary chart will suffice.

Agency Program Structure—the current list of programs and subprograms within the agency. Alternatively, a diagram illustrating the program hierarchy can be provided.

Plan for Monitoring and Tracking Performance—a description of the methods the agency is using to determine if the strategic plan is being accomplished. Emphasis should be placed on describing how progress to achieve the objective is currently being monitored by using performance measures, as well as describing the projected plan for each of the other future fiscal years. The description should evaluate the results of past actions implemented.

For example. The agency may note that it developed an action plan which it monitors monthly, while it compares actual performance data with planned targets on a quarterly basis.

Agencies may wish to indicate that they also plan to summarize overall progress in achieving the agency strategic plan in their annual report.

Other Information—Additional information to augment the agency’s strategic plan. This can include technical studies which may assist readers in understanding the plan, and/or a glossary of technical terms used in the text.

Strategic Plan Approval

All revised strategic plans must be approved by the Governor’s Office. All state agencies that report to an Agency Secretary must obtain the Agency Secretary’s approval of the department’s strategic plan. After the Agency Secretary approves the plan, the Agency Secretary will transmit the plan to the Governor’s Office (addressed to the appropriate deputy cabinet secretary) for Governor’s Office approval.

For state agencies that do not report to an Agency Secretary, the strategic plan must have the department director’s or executive officer’s approval and be transmitted to the appropriate Program Budget Manager (PBM) in the Department of Finance for review. After the PBM reviews the plan, it will be transmitted to the Governor’s Office for approval. Transmittal by the PBM does not indicate any budgetary approval or approval of any budget change proposal relating to the plan.
The Governor’s Office will forward a copy of an approved plan to the Department of Finance. The state agency will then be asked to send another two copies of its strategic plan, as approved, to the DOF Office of State Audits and Evaluations. The requirement of approval by the Governor’s Office shall not apply to elected constitutional offices. However, agencies headed by a elected constitutional office are subject to all other requirements of the budget process, including having a plan, approved by the elected constitutional office, that is linked to the budget.

These requirements shall not apply to the judicial branch of state government, the University of California and the California State University system. However, these organizations are encouraged to develop strategic plans for use in preparing their budgets and to forward copies of their plans to the Department of Finance.
APPENDIX D

HELP FOR THE PLANNING PROCESS

The following can provide helpful information about Strategic Planning:


C. *Statewide Plan Coordination in California*, Governor’s Office of Planning and Research, pages 39 to 41.

D. Workbooks.
   

E. *Strategic Planning Workshop*. A quarterly workshop/meeting for California state government strategic planners. For information contact the Strategic Planning Manager, (916) 657-8410, Department of Motor Vehicles, Strategic Planning Office, 2415 First Avenue, MS-C500, Sacramento, CA 95818.

F. *The California State Department of General Services*.

   The Department of General Services (DGS) makes available a Strategic and Management Consulting Services Master Agreement (DGS-ITEC-MC-962) with professional consulting firms who can assist agencies to develop strategic plans. It is effective from August 2, 1996 through June 30, 1999. For information regarding the user’s and selection guide for this agreement, please call the Information Technology & Education Center (ITEC) at (916) 324-6255 or (916) 322-9492.

   Costs for services vary. The approximate cost for consultants from the DGS list is $65 to $180 per hour. Additionally DGS charges a 2 percent administrative fee based on the consultant’s fees.
G. The California State Department of Personnel Administration.

Within the Department of Personnel Administration (DPA) the Office of Statewide Continuous Improvement (OSCI) assists California State departments in implementing the Governor’s Executive Order W-47-93 on quality government. The Office maintains a pre-qualified bidder’s list of many quality consultants on various topics which includes strategic planning. Any California State department can access OSCI’s list of consultants through a streamlined process involving an Interagency Agreement with DPA. The DPA usually charges a 10 percent administrative fee based on the consultant’s fees. For questions regarding this process or for referral of consultants, please call the Office of Statewide Continuous Improvement at (916) 323-4752.

Additionally, the State Training Center, administered by DPA, has a list of approved consultants, some of which provide strategic planning assistance. The approximate cost for consultants from the State Training Center list is $400 for a half-day session and $600 for a full day session plus travel and per diem.

H. Agencies may wish to find their own consultant through a Request for Proposal (RFP) process.

I. Agencies may choose to select an employee within their own organization who either possesses the expertise or is willing to be trained in strategic planning.
APPENDIX E

REFERENCES


2. Statewide Plan Coordination in California, October 1992, State of California, Governor’s Office of Planning and Research, Governor’s Interagency Council on Growth Management

3. Managing for Results, Strategic Planning and Performance Measurement Handbook, State of Arizona, May 1995, Governor’s Office of Strategic Planning and Budgeting, Governor’s Office for Excellence in Government


8. Management Memo 96-23 (State of California): Strategic Planning Requirements


Tribal History and Consultation

**Early California Laws and Policies Related to California Indians**
By Kimberly Johnston-Dodds, California Research Bureau

**Tribal Consultation Guidelines, Supplement to General Plan Guidelines**
By Governor’s Office of Planning and Research
Early California Laws and Policies Related to California Indians
By Kimberly Johnston-Dodds, California Research Bureau
Early California Laws and Policies Related to California Indians

By Kimberly Johnston-Dodds

ISBN 1-58703-163-9
Acknowledgements

The primary documents and sources reviewed for this report are located at the California State Archives, California State Library, Sacramento Archives and Museum Collection Center, and the Bancroft Library at the University of California, Berkeley. The secondary sources are located in the California State Library and University of California library collections.

Many people that work in these special collections and archives shared their knowledge, expertise and extended assistance in locating original bill files, legislative reports and rare documents, county records, and legal notices and accounts in California newspapers that were reviewed for this report. Their individual and collective efforts deserve mention and sincere thanks.

First, I especially thank Susan Hanks, Librarian in the Information Services Unit of the California Research Bureau, for her all her efforts related to this project, in particular for her tireless work searching the newspaper collections of the California History Section of the California State Library.

I thank all the librarians and staff of the California History Section, California State Library, for their assistance with my many, many requests for collection materials and searches. Special thanks are sent to John Gonzales, Catherine Hanson-Tracy, Ellen Harding, Jenny Hoye, Vickie Lockhart, and Lara Miyazaki. Special thanks are also sent to Gary Kurutz, Curator of Special Collections for the California State Library, for sharing with me his wisdom and encyclopedic memory of historic California sources and documents. I also sincerely thank David Cismowski, Librarian in the Government Publications Section, and Beth Owens, Senior Librarian in the Witkin State Law Library, California State Library, for sharing their expertise and assistance with the rare books and documents in these collections.

I thank the archivists and staff at the California State Archives for their extensive efforts and assistance related to my review of original bill files and legislative documents. I especially thank Melodi Andersen, Sydney Bailey, Jeff Crawford, Stephanie Hamishin, Linda Johnson, and Genevieve Troka.

Most importantly, many thanks to Roz Dick, Judy Hust, Trina Dangberg, and Joshua Mann for their professional editing, formatting and preparation of this report.
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Executive Summary

Did the State of California enact laws that prohibited California Indians from practicing their religion, speaking their languages or practicing traditional ceremonies and customs? Senator John L. Burton requested that the California Research Bureau research this question.¹

The initial investigation and research contained in this report² led to a focus on four examples of early State of California laws and policies that significantly impacted the California Indians’ way of life:

- The 1850 Act for the Government and Protection of Indians and related amendments;
- California militia policies and “Expeditions against the Indians” during 1851 to 1859;
- The State of California’s official response to federal treaties negotiated with California Indians during 1851 to 1852; and
- Early and current state fish protection laws that exempt California Indians from related prohibitions.

The 1850 Act for the Government and Protection of Indians facilitated removing California Indians from their traditional lands, separating at least a generation of children and adults from their families, languages, and cultures (1850 to 1865). This California law provided for “apprenticing” or indenturing Indian children and adults to Whites, and also punished “vagrant” Indians by “hiring” them out to the highest bidder at a public auction if the Indian could not provide sufficient bond or bail.

The California Legislature created the laws that controlled California Indians’ land, lives and livelihoods, while enforcement and implementation occurred at the county and local township levels. Some examples include:

- County-level Courts of Sessions and local township Justices of the Peace determined which Indians and Indian children were “apprenticed” or indentured pursuant to the 1850 Act for the Government and Protection of Indians.
- Under the same act, Justices of the Peace, mayors or recorders of incorporated towns or cities, decided the status and punishment of “vagrant” Indians.
- Under the California Constitution and state militia laws, California governors ordered local sheriffs to organize the men to conduct the “Expeditions against the Indians.”
From 1851 to 1859, the California Legislature passed twenty-seven laws that the State Comptroller relied upon in determining the total expenditures related to the Expeditions against the Indians. The total amount of claims submitted to the State of California Comptroller for these Expeditions against the Indians was $1,293,179.20.

The California Legislature was involved in influencing the U.S. Senate’s ratification process of the 18 treaties negotiated with California Indians during 1851 to 1852. These treaties were never ratified, and kept secret from 1852 until 1905. Prior to the President submitting the treaties to the Senate, the California Legislature conducted considerable debate, made reports, drafted and passed resolutions that mostly opposed ratification of the treaties.

The California Legislature also enacted laws during the first fifteen years of statehood that accommodated Indian tribes’ traditional fishing practices. California laws exist today that continue to protect fish and exempt California Indians from related prohibitions.
The First California Constitution, Suffrage and the California Indians

The creation of the first California Constitution and its governing framework set the stage for early laws related to California’s justice system, and California Indians.

In late 1849, the delegates to the California Constitutional Convention met to form the first constitution of California. At the Convention, the delegates debated the issue of whether California Indians should have the right to vote. A minority advocated that the Indians should have the right to vote, as was recognized by the prior Mexican regime, especially if the Indians were going to be taxed. The minority delegates cited principles in the Declaration of Independence declaring that taxation and representation go together. However, other delegates in the majority argued that certain influential white persons who controlled Indians would “march hundreds [of wild Indians] up to the polls” to cast votes in compliance with such persons’ wishes.

In the end, the majority prevailed and the Convention agreed to the following constitutional provisions regarding suffrage and California Indians:

Every white male citizen of the United States, and every white male citizen of Mexico, who shall have elected to become a citizen of the United States, under the treaty of peace exchanged and ratified at Queretaro, on the 30th day of May, 1848, of the age of twenty-one years, who shall have been a resident of the State six months...shall be entitled to vote at all elections which are now or hereafter may be authorized by law:

Provided, that nothing herein contained shall be construed to prevent the Legislature, by a two thirds concurrent vote, from admitting to the right of suffrage, Indians or the descendants of Indians, in such special cases as such a proportion of the legislative body may deem just and proper.

The California Legislature never passed legislation that allowed California Indians to vote.

In 1870, Congress ratified the 15th Amendment of the U.S. Constitution affirming the right of all U.S. citizens to vote:

The right of citizens of the United States to vote shall not be denied or abridged by the United States or by any State on account of race, color, or previous conditions of servitude.

However, even after the 15th Amendment was ratified, most American Indians, including California Indians, did not have the right to vote until the federal Citizenship Act of 1924 was passed.
1850: An Act for the Government and Protection of Indians

Soon after the creation of the California Constitution and before the U.S. Congress granted California statehood, the first California Legislature reviewed an important piece of Indian legislation: the first version failed to become law, the second version became law on the last day of the session.

The first California Legislature passed An Act for the Government and Protection of Indians on April 22, 1850. Initially introduced as Senate Bill No. 54 - An Act relative to the protection, punishment and government of Indians on March 16, 1850, by Senator Chamberlin, at the request of Senator Bidwell. Senate Bill No. 54 was “laid on the table,” on March 30, and went no further in the legislative process.

On April 13, 1850, Assemblyman Brown introduced Assembly Bill No. 129, An Act for the government and protection of Indians. The Legislature passed the bill on April 19, after the Senate amended Section 16 to decrease the whipping punishment for Indians from 100 to 25 lashes. The Governor signed it into law on April 22, four months before California became the 31st state in the Union (on September 9, 1850). The Act for the Government and Protection of Indians was not repealed in its entirety until 1937.

LOSS OF LANDS AND CULTURES

The 1850 Act and subsequent amendments10 facilitated removing California Indians from their traditional lands, separating at least a generation of children and adults from their families, languages, and cultures (1850 to 1865), and indenturing Indian children and adults to Whites.

The relevant sections provided that:

- White persons or proprietors could apply to the Justice of the Peace for the removal of Indians from lands in the white person’s possession.
- Any person could go before a Justice of the Peace to obtain Indian children for indenture. The Justice determined whether or not compulsory means were used to obtain the child. If the Justice was satisfied that no coercion occurred, the person obtained a certificate that...

---

1All of the provisions contained in the initial Act of 1850 are described in Appendix 1, which also contains footnoted comparisons of the language contained in the enacted law and amendments, and original Assembly and Senate bill language that was not incorporated into the 1850 Act.

1 Webster’s Dictionary defines “indenture” as a contract by which a person is bound to service. It is well known that the Hispanic missions in California that governed before the United States and the State of California, used forced Indian labor to build the missions and work in the surrounding agricultural lands.
authorized him to have the care, custody, control and earnings of an Indian minor, until their age of majority (for males, eighteen years, and females, fifteen years).

- If a convicted Indian was punished by paying a fine, any white person, with the consent of the Justice, could give bond for the Indian’s fine and costs. In return, the Indian was “compelled to work until his fine was discharged or cancelled.” The person bailing was supposed to “treat the Indian humanely, and clothe and feed him properly.” The Court decided “the allowance given for such labor.”

**ABSENCE OF LEGAL RIGHTS**

In 1850 and 1851, the California Legislature enacted laws concerning crimes and punishments that prohibited Indians, or black or mulatto persons, from giving “evidence in favor of, or against, any white person.” The 1850 statute defined an Indian as having one-half Indian blood. The 1851 statute defined an Indian as “having one fourth or more of Indian blood.”

**Inequitable Due Process**

The 1850 Act for the Government and Protection of Indians evidences further absence of legal rights for California Indians. The 1850 Act provided that:

- Justices of the Peace had jurisdiction in all cases of complaints related to Indians, without the ability of Indians to appeal at all, including to higher courts of record such as district courts or courts of sessions.

- While Indians or white persons could make complaints before a Justice of the Peace, “in no case [could] a white man be convicted of any offen[s]e upon the testimony of an Indian, or Indians.”

- Justices of the Peace were to “instruct the Indians in their neighborhood in the laws which related to them.” Any tribes or villages refusing or neglecting to obey the laws could be “reasonably chastised.”

- If an Indian committed “an unlawful offen[s]e against a white person,” the person offended was not allowed to mete out the punishment. However, the offended white person could, without process, bring the Indian before the Justice of the Peace, and on conviction the Indian was punished.

* The term “reasonably chastised” became a basis of a state policy empowering and paying the militia to attack Indians, as discussed in the next section.

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California Research Bureau, California State Library
Justices of the Peace

The first California Constitution provided that the “Legislature shall determine the number of Justices of the Peace, to be elected in each county, city, town, and incorporated village of the State, and fix by law their powers, duties, and responsibilities.”

In 1850, the first California Legislature provided that the jurisdiction of Justices of the Peace was limited to the township where they were elected. Some of the powers and responsibilities conferred upon the first Justices of the Peace:

- authorized them to hear, try and determine civil cases when the amount claimed was $200 or less (later raised to $500 in 1853).
- required them to take an oath and give a bond “in the penalty of five thousand dollars, conditioned for the faithful performance of [their] duties.”
- empowered them to be a magistrate, an “officer having power to issue a warrant for the arrest of a person charged with a public offence.”

Throughout the period from 1850 into the 1860s, Justices of the Peace also presided over Justice Courts within their township jurisdictions. These courts were not courts of record, and had both civil and criminal jurisdiction to hear actions on:

- contracts for payment of money,
- injuries to a person or taking or damaging personal property,
- statutory fines, penalties and forfeitures,
- mining claims within their jurisdiction,
- petty larceny, assault and battery (if not committed on a public officer), and
- breaches of the peace, riots, and all misdemeanors punishable by fine not exceeding $500 or imprisonment not exceeding three months, or both.

The Justice Courts also held proceedings related to “vagrants and disorderly persons.”

Justices of the Peace for Indians

The first bill introduced related to the 1850 Act (Senate Bill No. 54) provided for Justices of the Peace for Indians, but it was not enacted. These Justices of the Peace were to be elected by the Indians directly, at the order and direction of the Court of Sessions. The

* See Appendix 3 for discussion of the Court of Sessions.
bill provided that the Inspectors of Elections appointed by the Court “procure one or more interpreters to be at the polls during the election who shall ask every Indian who is entitled to vote, whom he prefers for Justice for the Indians the ensuing year, and his vote shall be recorded for the person he prefers.”19 This language that created Justices of the Peace for Indians was not contained in the companion bill proposed by the Assembly, nor the final law enacted in 1850. (As previously discussed in an earlier section, the first California Constitution excluded Indians from the right to vote.)

VAGRANCY AND PUNISHMENT UNDER “AN ACT FOR THE GOVERNMENT AND PROTECTION OF INDIANS”

Section 20 of the 1850 Act defined “vagrant” Indians and prescribed their punishment:

Any Indian able to work and support himself in some honest calling, not having wherewithal to maintain himself, who shall be found loitering and strolling about, or frequenting public places where liquors are sold, begging, or leading an immoral or profligate course of life, shall be liable to be arrested on the complaint of any resident citizen of the county, and brought before any Justice of the Peace of the proper county, Mayor or Recorder of any incorporated town or city, who shall examine said accused Indian, and hear the testimony in relation thereto, and if said Justice, Mayor, or Recorder shall be satisfied that he is a vagrant...he shall make out a warrant under his hand and seal, authorizing and requiring the officer having him in charge or custody, to hire out such vagrant within twenty-four hours to the best bidder, by public notice given as he shall direct, for the highest price that can be had, for any term not exceeding four months.19

Monies received from hiring such Indians, after deducting housing and clothing costs, were to be deposited into an “Indian fund” administered by the County Treasury (if he did not have a family). The “vagrant” Indian, after arrest but before judgment, could post a bond with a condition that for the next 12 months he would “conduct himself with good behavior, and betake some honest employment for support.”20

AMENDMENTS TO “AN ACT FOR THE GOVERNMENT AND PROTECTION OF INDIANS”

In 1855, Section 6 of the 1850 Act was amended to read “Complaints may be made before a Justice of the Peace, by white men or Indians, and in all cases arising under this Act, Indians shall be competent witnesses, their credibility being left with the jury.”21 However, California legal treatises of the 1860s continued to cite the general civil procedure laws that excluded Indians from being witnesses at court as valid law.22

In 1860, the California Legislature amended Sections Three and Seven of the 1850 Act. These amendments granted broad powers to county and district judges to, when requested, execute articles of indenture of apprenticeship on behalf of Indians. The 1860
amendments to the Act also provided that male Indian children under fourteen years could be indentured until they were twenty-five, and females under fourteen until they were twenty-one years old. If they were over fourteen but under twenty, males were indentured until they were thirty, and females until they were twenty-five years. Indians over twenty years old could be indentured for an additional ten years.\textsuperscript{22} Due in part to a decade of state-financed expeditions against the Indians, there were many young Indian children without parents.

In 1863, Section Three of the 1850 Act was repealed. However, historical accounts drawn from primary sources indicate that this system of Indian indentured servitude continued, even after Section Three was repealed (see page 11).

In 1865, the California Supreme Court ruled that the section of the 1850 Act related to whipping was unconstitutional because the punishment was cruel and unusual.\textsuperscript{24}

**HISTORICAL ACCOUNTS ABOUT INDENTURES, KIDNAPPING AND SELLING OF INDIANS**

**Articles of Indenture**

I reviewed original indentures of Indians dated 1861, in the Sacramento County Archives.\textsuperscript{25} The original text of one of the indentures follows:

In the Matter of the Indenture of...the Indian boy Bill (aged 15 years or thereabouts) to William Moorhead

To the Hon Robert Robinson County Judge of the City & County of Sacramento –

William Moorhead of the City & County of Sacramento in the State of California respectfully shows that he has an Indian boy called “Bill” under his control and management & that he has faithfully provided for said boy Bill for the last five years or thereabouts. That he formerly belonged to a Tribe called “Cottonwood” tribe in Shasta County in said State that the said boys [sic] parents, as petitioner is informed, and believes, have been dead for several years, and that the said boy has been living with petitioner in the City of Sacramento & working about petitioners [sic] livery stable. Petitioner further shows that he has provided said boy with all the necessaries of life & rendered him happy & contented.

Petitioner further shows that he has reason to believe & does believe that unless the said boy shall be apprenticed in accordance with the provisions of an act entitled “an act amendatory of an act entitled an act for the government and protection of Indians passed passed [sic] April 22, 1850” approved April 18, 1860 some persons will induce the said Indian boy to leave petitioner, & that he may become a vagrant, & addicted to dissolute habits[ sic].
Petitioner therefore prays that Indentures may be made in accordance with said act and the said boy forthwith apprenticed to petitioner until he shall attain the age of thirty years.26

The County Judge, Robert Robinson, approved and signed the document with the notation: “Boy indentured as provided by law.”27

In 1971, Robert Heizer and Alan Almquist published the findings of their review of 114 indentures dated from 1860 to 1863, located in old county court files in Eureka, California. In addition to publishing the name, probable age, period of indenture and/or age indentured to, Heizer and Almquist summarize the data:

Ages of 110 persons indentured range from two to fifty, with a concentration of 49 persons between the ages of seven and twelve. Seven are listed as “taken in war” or prisoners of war”—this notation refers to children five, seven, nine, ten, and twelve years of age. Four children of ages eight, nine ten, and eleven are listed as “bought” or “given.” Ten married couples were indentured, some of them with children. Three individuals seem almost too young to have been so treated—Perry, indentured in September 1860 at the age of three; George, indentured in January 1861 at the age of four; and Kitty (November 1861), also four years of age.28

Some of the indentures cited by Heizer and Almquist were made after the 1863 amendment that repealed Section 3 of the 1850 Act.29

Appendix 4 of this report is a copy of an article of indenture, located in the records of Humboldt County, published in the Sacramento Daily Union on February 4, 1861.

Accounts of Kidnapping and Selling of Indians

The following are accounts published in California newspapers as legal notices and articles from 1855 to 1864. These articles document incidents of kidnapping and selling of California Indian children.

Alta California - 1855

One of the most infamous practices known to modern times has been carried on for several months past against the aborigines of California. It has been the custom of certain disreputable persons to steal away young Indian boys and girls, and carry them off and sell them to white folks for whatever they could get. In order to do this, they are obliged in many cases to kill the parents, for low as they are on the scale of humanity, they [the Indians] have that instinctive love of their offspring which prompts them to defend them at the sacrifice of their lives.30
San Francisco Herald - 1856

In the Fourth District Court yesterday…for the hearing of the return to the writ of *habeas corpus* issued to produce the body of Shasta, the Indian girl claimed by Dr. Wozencraft, Charlotte Sophie Gomez appeared…and made the following return as to the cause of her inability to produce Shasta:

“That an Indian child by the name of Isabella, not about eight years of age, has lived in her family since the month of June, 1852, at her residence in the city of San Francisco. That during the last three years, or thereabouts, the said child has attended the public day school in said city. That…Isabella has resided with…Gomez until last Monday. On that day, about five o’clock in the afternoon, a person presented himself at her residence and told her that said Indian child belonged to him, and wanted to take her away. Of this fact she was told by a member of her family…Gomez says she has no knowledge of the person who took the child from her house, nor does she know where she now is, or has been, since taken away therefrom...”

…It is the belief of Dr. Wozencraft that the girl, Isabella…is the one that has been stolen from him. He is most anxious to recover Shasta and will use every legal means to recover possession of her.31

Alta California - 1862

The *Ukiah Herald*, published in Mendocino county, has a long article upon the practice of Indian stealing so extensively carried on in that section of the country, and says that one woodman has been caught with sixteen young Indians in his possession, being about to take them out of the county for sale. The *Herald* says:

“Here is well known there are a number of men in this county, who have for years made it their profession to capture and sell Indians, the price ranging from $30 to $150, according to quality. Some hard stories are told of those engaged in the trade, in regard to the manner of the capture of the children. It is even asserted that there are men engaged in it who do not hesitate, when they find a rancheria well stocked with young Indians, to murder in cold blood all the old ones, in order that they may safely possess themselves of all the offspring.”32

The *Alta California* comments at the end of the 1862 article that the *Ukiah Herald* account “affords a key to the history of border Indian troubles.”

The next account is found in the journal of William H. Brewer, one of the members of the original California Geological Survey mandated by the California Legislature in 1860.33 Brewer traveled throughout California from 1860 to 1864, providing official reports under the survey.
The Indian wars now going on, and those which have been for the last three years in the counties of Klamath, Humboldt, and Mendocino, have most of their origin in this. It has for years been a regular business to steal Indian children and bring them down to the civilized parts of the state, even to San Francisco, and sell them – not as slaves, but as servants to be kept as long as possible. Mendocino County has been the scene of many of these stealings, and it is said that some of the kidnappers would often get the consent of the parents by shooting them to prevent opposition.
Early California Apprenticeship and Vagrancy Laws

Apprenticeship and vagrancy laws and policies related to the general population existed in California during the first two decades of statehood. However, they were enacted after the 1850 Act related to California Indians, and the penalties under these laws were less severe when applied to the non-Indian population.

An 1853 California legal treatise entitled A Treatise on the Practice of the Courts of the State of California, Carefully Adapted to Existing Law, first mentions apprenticeship and minors when describing exceptions to the general rule that minors could not make a contract:

[T]here are two exceptions to the general rule that minors cannot contract. The one case is contracts for apprenticeship. Minors can bind themselves as apprentices for seven years by deed, if the seven years are within their maturity. The other case is in contracts for necessaries. What are necessaries is frequently a question hard to resolve. What would be necessaries for one, would not be for another. Necessary boarding, clothing, and lodging, and medical attendance in sickness, tuition of necessary teachers – these are necessaries. The age and sex of the minor, the real station in society, property and business or vocation selected for life, all these things are necessarily involved in the question.

1858 - AN ACT TO PROVIDE FOR BINDING MINORS AS APPRENTICES, CLERKS AND SERVANTS

The first apprenticeship law in California related to non-Indians, An Act to provide for Binding Minors as Apprentices, Clerks and Servants, was enacted in 1858, almost a decade after the 1850 Act. There were significant differences between the two laws. The 1858 Act excluded Indians (1/4 blood) from its provisions. The 1858 Act mandated that

- the indenture state every sum of money paid or agreed for in relation to the apprenticeship.
- the person to whom a child was bound send the child to school three months of each year of the period of the indenture to learn to read, write and the general rules of arithmetic.

The 1858 Act also provided that an indenture of apprenticeship could be annulled and voided in the event that a county court found

- fraud in the contract of indenture.
- the contract was not made or signed pursuant to the law.
- willful nonfulfillment of the indenture provisions by the master.
cruelty or maltreatment of the apprentice by the master, without cause or
provocation.39

In 1865, Congress ratified the 13th Amendment of the U.S. Constitution. The
states had to comply with the newly ratified amendment abolishing slavery and
involuntary servitude:

Neither slavery nor involuntary servitude, except as punishment for crime
whereof the party shall have been duly convicted, shall exist within the
United States, or any place subject to their jurisdiction.

**1855 – An Act to Punish Vagrants, Vagabonds, and Dangerous and
Suspicious Persons**

The first vagrancy law of California that applied to others was passed April 30, 1855.
The penalties under the law were less severe than the penalties imposed against Indians
under the 1850 Act. The 1855 Act provided that

All persons except Digger Indians, who have no visible means of living,
who in ten days do not seek employment, nor labor when employment is
offered to them, all healthy beggars, who travel with written statements of
their misfortunes, all persons who roam about from place to place without
any lawful business, all lewd and dissolute persons who live in and about
houses of Ill-Fame; all common prostitutes and common drunkards may
be committed to jail and sentenced to hard labor for such time as the
Court, before whom they are convicted shall think proper, not exceeding
ninety days.40

The law did not define “Digger Indians.” The Justice of the Peace enforced the
vagrancy laws, and the county Board of Supervisors determined the type of labor
the convicted person was to perform.41

In 1863, the California Legislature amended the law to exempt California Indians from
the provisions of the 1855 Act.42 The vagrancy provisions contained in the 1850 Act
relating to the California Indians (previously described) were not repealed until 1937.
1850 - 1859: California Militia and “Expeditions Against the Indians”

That a war of extermination will continue to be waged between the races, until the Indian race becomes extinct, must be expected. While we cannot anticipate this result but with painful regret, the inevitable destiny of the race is beyond the power or wisdom of man to avert.

Governor Peter H. Burnett, January 7, 1851

THE GOVERNORS AND THE MILITIA

Article VII of the first California Constitution gave the Governor the power “to call for the militia, to execute the laws of the State, to suppress insurrections, and repel invasions.” In his annual address to the California Legislature on January 7, 1851, Governor Burnett highlighted significant events that transpired during 1850, including “repeated calls…upon the Executive for the aid of the militia to resist and punish the attacks of the Indians upon the frontier.” During 1850, Governor Burnett called out the militia two times. The first order was prompted by incidents at the confluence of the Gila and Colorado rivers on April 23, 1850; in response, the Governor ordered the sheriffs of San Diego and Los Angeles to organize a total of 100 men to “pursue such energetic measures to punish the Indians, bring them to terms, and protect the emigrants on their way to California.”

Governor Burnett explained calling out the militia as follows:

In these cases the [Indian] attacks were far more formidable, and made at point where the two great emigrant trails enter the State…occurred at a period when the emigrants were arriving across the plains with their jaded and broken down animals, and them destitute of provisions. Under these circumstances, I deemed it due to humanity, and to our brethren arriving among us in a condition so helpless, to afford them all the protection within the power of the State…

Had it been once known to our fellow citizens east of the Rocky Mountains, that the Indians were most hostile and formidable on the latter and more difficult portion of the route…and that the State of California would render no assistance to parties so destitute, the emigration of families to the State across the plains would have been greatly interrupted and retarded.

From 1997 to 1999, the Sacramento Genealogical Society researched and compiled an extensive index of the State Militia Muster Rolls located in the California State
The California State Archives contain Muster Rolls or organizational documents for 303 units located in most California counties. Seventy-one of the militias were located in San Francisco. After exhaustive review and crosschecking of 70,000 registered names, the researchers determined that approximately 35,000 men were listed on the Muster Rolls (attendance records).

From the state archival record, it is impossible to determine exactly the total number of units and men engaged in attacks against the California Indians. However, during the period of 1850 to 1859, the official record does verify that the governors of California called out the militia on “Expeditions against the Indians” on a number of occasions, and at considerable expense, as Tables 1 and 2 indicate.

Table 1

<table>
<thead>
<tr>
<th>Expeditions Against the Indians</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mariposa and Monterey</td>
<td>$259,372.31</td>
</tr>
<tr>
<td>First El Dorado</td>
<td>101,861.65</td>
</tr>
<tr>
<td>Second El Dorado</td>
<td>199,784.59</td>
</tr>
<tr>
<td>Los Angeles and Utah</td>
<td>96,184.60</td>
</tr>
<tr>
<td>Trinity, Klamath and Clear Lake</td>
<td>34,320.08</td>
</tr>
<tr>
<td>San Diego “Fitzgerald Volunteers”</td>
<td>22,581.00</td>
</tr>
<tr>
<td>Siskiyou “Volunteer Rangers”</td>
<td>14,987.00</td>
</tr>
<tr>
<td>Gila “Colorado Volunteers”</td>
<td>113,482.25</td>
</tr>
<tr>
<td>Amount paid in War Bonds by Paymasters</td>
<td>1,000.00</td>
</tr>
<tr>
<td><strong>Total Amount</strong></td>
<td><strong>$843,573.48</strong></td>
</tr>
</tbody>
</table>


*Muster Rolls may exist in other county or local archival repositories. The California State Archives does not have Muster Rolls for Colusa, Fresno, Glenn, Imperial, Inyo, Kern, Kings, Lake, Madera, Mendocino, Merced, Modoc, Riverside, San Benito, and Ventura counties for the period 1851 to 1866.*
THE CALIFORNIA LEGISLATURE AND THE MILITIA

In April 1850, the California Legislature enacted two laws: An Act concerning Volunteer or Independent Companies,\(^\text{52}\) and An Act concerning the organization of the Militia.\(^\text{53}\) The Volunteer Act provided that citizens of any one county could:

- organize into a volunteer or independent company;
- arm and equip themselves in the same manner as the army of the United States;
- prepare muster rolls (attendance records) twice a year; and
- render prompt assistance and full obedience when summoned or commanded under the law.\(^\text{54}\)

The lengthy Militia Act established in great detail the organization, ranks, rules, duties and commutation fees (fees in lieu of service) that governed state military service. All “free, white, able-bodied male citizens, between the ages of eighteen and forty-five years, residing in [the] State” were subject to state-mandated military duty.\(^\text{55}\) Important provisions relating to the delegation of authority to command and call out troops provided that:

- the Governor was the commander in chief of all the forces in the state;
- the Legislature elected four Major Generals, eight Brigadier Generals, one Adjutant General and Quarter Master General (with Brigadier General rank);
- the Governor commissioned all of the officers under the Act, who then took the oath of office prescribed by the California Constitution;
- the State Treasurer initially was the ex officio Pay Master; and
- upon the Governor’s orders, the Sheriffs of each county were responsible to call the enrolled militia.\(^\text{56}\)

In 1851, two laws set the rates of pay for the troops.\(^\text{57}\) As shown in Table 2, Federal authorities considered the rates exorbitant in comparison to compensation to federal troops.\(^*\)

\(^*\) The 1850 Volunteer Act and Militia Act were repealed and replaced in 1855, and amended in 1856 and 1857. The National Guard replaced the California Militia in 1866. 1855 Cal. Stat. ch. 115; 1856 Cal. Stat. ch. 87; 1857 Cal. Stat. 344; 1866 Cal. Stat. ch. 541; Sacramento Genealogical Society, California State Militia, ii.
Table 2 details the State’s expenditures for expeditions from 1854 to 1859.

### Table 2

<table>
<thead>
<tr>
<th>Expedition</th>
<th>Year</th>
<th>Amount Allowed by California*</th>
<th>Amount Allowed by United States**</th>
<th>Amount Disallowed by United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shasta Expedition</td>
<td>1854</td>
<td>4,068.64</td>
<td>1,261.38</td>
<td>2,807.26</td>
</tr>
<tr>
<td>Siskiyou Expedition</td>
<td>1855</td>
<td>14,036.36</td>
<td>6,146.60</td>
<td>7,889.76</td>
</tr>
<tr>
<td>Klamath &amp; Humboldt Expedition</td>
<td>1855</td>
<td>99,096.65</td>
<td>61,537.48</td>
<td>37,559.17</td>
</tr>
<tr>
<td>San Bernardino Expedition</td>
<td>1855</td>
<td>817.03</td>
<td>419.99</td>
<td>397.04</td>
</tr>
<tr>
<td>Klamath Expedition</td>
<td>1856</td>
<td>6,190.07</td>
<td>2953.77</td>
<td>3,237.30</td>
</tr>
<tr>
<td>Modoc Expedition</td>
<td>1856</td>
<td>188,324.22</td>
<td>80,436.72</td>
<td>107,887.50</td>
</tr>
<tr>
<td>Tulare Expedition</td>
<td>1856</td>
<td>12,732.23</td>
<td>3,647.25</td>
<td>9,084.98</td>
</tr>
<tr>
<td>Klamath &amp; Humboldt Expedition</td>
<td>1858 &amp; 1859</td>
<td>52,184.45</td>
<td>31,823.94</td>
<td>20,360.51</td>
</tr>
<tr>
<td>Pitt River Expedition</td>
<td>1859</td>
<td>72,156.09</td>
<td>41,761.54</td>
<td>30,394.55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$449,605.74</strong></td>
<td><strong>$229,987.67</strong></td>
<td><strong>$219,618.07</strong></td>
</tr>
</tbody>
</table>


*Amount submitted to the United States for reimbursement.

**Amount actually paid by the United States.

Table 3 sets forth the twenty-seven California laws that the State Comptroller relied upon in determining the total expenditures recapitulated in the official report. The total amount of claims submitted to State of California Comptroller for Expeditions against the Indians was $1,293,179.20.
Table 3

Laws and Joint Resolutions Passed Relative to the Indian Wars in the State of California
1851-1859

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Date</th>
<th>Page</th>
<th>Description of Act or Joint Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statute</td>
<td>1851</td>
<td>489</td>
<td>Creating William Foster &amp; William Rogers Pay Masters</td>
</tr>
<tr>
<td>Statute</td>
<td>1851</td>
<td>402</td>
<td>Creating James Burney Pay Master to pay Troops</td>
</tr>
<tr>
<td>Statute</td>
<td>1851</td>
<td>520</td>
<td>To negotiate a loan for the War Fund $500,000</td>
</tr>
<tr>
<td>Joint Resolution</td>
<td>1851</td>
<td>530</td>
<td>To Establish Forts on our Borders</td>
</tr>
<tr>
<td>Joint Resolution</td>
<td>1851</td>
<td>532</td>
<td>Directing Adjutant General to enter names on Muster Roll</td>
</tr>
<tr>
<td>Joint Resolution</td>
<td>1851</td>
<td>534</td>
<td>Reference to the payment of claims and informal transfers in writing</td>
</tr>
<tr>
<td>Joint Resolution</td>
<td>1851</td>
<td>535</td>
<td>Reference to the payment of certain claims in the Gila Expedition</td>
</tr>
<tr>
<td>Joint Resolution</td>
<td>1851</td>
<td>538</td>
<td>Authorizing the Pay Master of the Gila Expedition to pay claims</td>
</tr>
<tr>
<td>Joint Resolution</td>
<td>1851</td>
<td>539</td>
<td>For the Benefit of the Citizens of Los Angeles County</td>
</tr>
<tr>
<td>Statute</td>
<td>1852</td>
<td>59</td>
<td>Authorizing the Treasurer to issue Bonds for $600,000</td>
</tr>
<tr>
<td>Statute</td>
<td>1852</td>
<td>61</td>
<td>Authorizing and requiring Board of Examiners to settle with William Rogers</td>
</tr>
<tr>
<td>Statute</td>
<td>1852</td>
<td>250</td>
<td>For the relief of James S. Bolen</td>
</tr>
<tr>
<td>Statute</td>
<td>1852</td>
<td>261</td>
<td>For the relief of Jacob C. Kore</td>
</tr>
<tr>
<td>Statute</td>
<td>1852</td>
<td>262</td>
<td>For the relief of John G. Warrin</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>79</td>
<td>For the relief of Thomas A. Wilton, M.D.</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>95</td>
<td>To pay troops under Captain Wright S. McDermott $23,000</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>97</td>
<td>For the relief of Beverly C. Sanders</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>130</td>
<td>For the relief of John C. Johnson</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>134</td>
<td>Additional War Fund $23,000</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>154</td>
<td>For the relief of A.D. Blanchard and Samuel Stephens</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>177</td>
<td>Secretary of State constituted one of the Board of Examiners</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>177</td>
<td>Providing for the pay and compensation of Major James Burney</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>200</td>
<td>For the relief of John Brown $1,150</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>225</td>
<td>Payment of the Fitzgerald Volunteers</td>
</tr>
<tr>
<td>Statute</td>
<td>1853</td>
<td>268</td>
<td>For the relief of John W. Jackson</td>
</tr>
<tr>
<td>Joint Resolution</td>
<td>1853</td>
<td>310</td>
<td>General Statement of War Debt to be made out</td>
</tr>
<tr>
<td>Statute</td>
<td>1854</td>
<td>171</td>
<td>For the relief of Powell Weaver</td>
</tr>
</tbody>
</table>

Source: Comptroller of the State of California, Expenditures for Military Expeditions Against Indians, 1851-1859, (Sacramento: The Comptroller), Secretary of State, California State Archives, Located at “Roster” Comptroller No. 574, Vault, Bin 393.
1860: The Legislature’s Majority and Minority Reports on the Mendocino War

In 1860, the California Legislature created a Joint Special Committee on the Mendocino Indian War to investigate incidents of Indian stealing and killing of settlers’ stock, and alleged atrocities committed by whites against the Indians.

The Joint Special Committee traveled throughout Mendocino County and adjacent locations taking depositions and testimony of prominent settlers in the region. This testimony is part of the official public record, along with the committee’s majority and minority reports about the events.

The Majority Report of the Joint Special Committee

O’Farrell, Dickinson, Maxon and Phelps were authors of the Majority Report. The following are excerpts of the majority’s findings, conclusions, and recommendations.

In Mendocino County…the Indians have committed extensive depredations on the stock of the settlers…The result has been that the citizens, for the purpose of protection to their property, have pursued the tribes supposed to be guilty to their mountain retreats, and in most cases have punished them severely. Repeated stealing and killing of stock, and an occasional murder of a white man, has caused a repetition of the attacks upon the offenders with the same results. The conflict still exists; Indians continue to kill cattle as a means of subsistence, and the settlers in retaliation punish with death. Many of the most respectable citizens of Mendocino County have testified before your committee that they kill Indians, found in what they consider the hostile districts, whenever they lose cattle or horses; nor do they attempt to conceal or deny this fact. Those citizens do not admit, nor does it appear by the evidence, that it is or has been their practice or intention to kill women or children, although some have fallen in the indiscriminate attacks of the Indian rancherias. The testimony shows that in the recent authorized expedition against the Indians in said county, the women and children were taken to the reservations, and also establishes the fact that in the private expeditions this rule was not observed, but that in one instance, an expedition was marked by the most horrid atrocity; but in justice to the citizens of Mendocino County, your committee say that the mass of the settlers look upon such act with the utmost abhorrence…

* The Joint Special Committee was comprised of Jasper O’Farrell (Sonoma, Marin, Mendocino), and W.B. Dickinson (El Dorado), as the Senate Committee. Joseph B. Lamar (Mendocino, Sonoma), William B. Maxon (San Mateo) and Abner Phelps (San Francisco) comprised the House Committee. Don A. Allen, Legislative Sourcebook: The California Legislature and Reapportionment, 1849-1965, (Sacramento: Assembly of the State of California, 1965), 364, 374, 450, 456.
Accounts are daily coming in from the counties on the Coast Range, of sickening atrocities and wholesale slaughters of great numbers of defenseless Indians in that region of country. Within the last four months, more Indians have been killed by our people than during the century of Spanish and Mexican domination. For an evil of this magnitude, some one is responsible. Either our government, or our citizens, or both, are to blame…

The pre-existing laws and policy of Mexico, as to the status of the Indian, need not have interfered with the views to be taken by our government. Mexico protected the Indian, in her own way, much more effectually than we have done. The very land upon which the aborigines of this State have dwelt, as far back as traditions reach, has been allowed by our government to be occupied by settlers, who thus have the authority of law for a forced occupation of the Indian country. A natural, humane, and proper policy would have protected the Indian in his undeniable rights to the hunting grounds of his forefathers, and would have prevented our border men from entering into a conflict which has cost both lives and property…

Your committee do not think that the wrongs committed upon the Indians of California are chargeable alone to the Federal Government. The evidence appended to this report, disclose facts, from the contemplation of which the mind of peaceful citizens recoil with horror, and prompts the inquiry, if such outrages upon the defenseless are permitted by the proper authorities to go unpunished?

No provocation has been shown, if any could be, to justify such acts. We must admit that the wrong has been the portion of the Indian—the blame with his white brother.

The question resolves itself to this: Shall the Indians be exterminated, or shall they be protected? If the latter, that protection must come from the Federal Government, in the form of adequate appropriations of money and land; and secondly, from this State, by strictly enforcing penal statutes for any infringement upon the rights of Indians.

In relation to the recent difficulty between the whites and Indians in Mendocino County, your committee desire to say that no war, or a necessity for a war, has existed, or at the present time does exist. We are unwilling to attempt to dignify, by the term “war” as slaughter of beings, who at least possess human form, and who make no resistance, and make no attacks, either on the person or residence of the citizen.

The authors of the Majority Report recommended that the California Legislature pass “a law for the better protection of the Indians of California.”
The Minority Report of the Special Joint Committee

Lamar authored the Minority Report and dissented fundamentally from the majority’s view of the events, and their recommendations. Lamar stated, “the testimony will disclose the guilty parties, and from the just indignation of outraged humanity I have no desire to screen them; but for the mass of citizens engaged in this Indian warfare, I claim that they have acted from the strongest motives that govern human action—the defense of life and property.”60

Lamar further stated that certain tribes living outside of reservations in the region were “domesticated Indians,” a great number of whom were employed by settlers, receiving “liberal compensation for their labor.”61 Lamar proposed the following general Indian policy that the State should pursue.

The General Government should first cede to the State of California the entire jurisdiction over Indians and Indian affairs within our borders, and make such donations of land and other property and appropriations of money as would be adequate to make proper provision for the necessities of a proper management.

The State should, then, adopt a general system of peonage or apprenticeship, for the proper disposition and distribution of the Indians by families among responsible citizens. General laws should be passed regulating the relations between the master and servant, and providing for the punishment of any meddlesome interference on the part of third parties. In this manner the whites might be provided with profitable and convenient servants, and the Indians with the best protection and all the necessaries of life in permanent and comfortable homes.62

The Mendocino War Reports and the 1860 Amendment to “An Act for the Government and Protection of Indians”

On January 19, 1860, the first version of Assembly Bill No. 65, entitled “An Act amendatory of an Act for the Government and Protection of Indians” was introduced in the California Legislature.63 Assembly Bill No. 65 proposed broader apprenticeship laws than those contained in the 1850 Act. Various amendments and substitute versions of the bill found in the California State Archives Original Bill File appear to reflect the degree of debate surrounding Indian prisoners of war from expeditions, Lamar’s proposed Indian policies, and more expansive Indian apprenticeship laws. Transcriptions of the proposed versions of the bill, and the original enrolled version are contained in Appendix 2 of this report.
1851-1852: California’s Response to Federal Treaties Negotiated with the Indians

Among the more immediate causes that have precipitated this state of [frontier hostilities], may be mentioned the neglect of the General Government to make treaties with [the Indians] for their lands. We have suddenly spread ourselves over the country in every direction, and appropriated whatever portion of it we pleased to ourselves, without their consent, and without compensation.

Governor Peter H. Burnett, January 7, 1851

From 1851 through early 1852, the U.S. Indian Commissioners, acting on behalf of the United States, negotiated 18 treaties with California Indian tribes. A number of aspects surrounding the negotiations were fraught with problems and controversy, in large part due to the ambiguous scope of authority delegated to the Commissioners by the federal government, and inadequate appropriations provided to carry out their job. The treaties negotiated by the Indian Commissioners reserved to the Indians approximately 11,700 square miles, or about 7.5 million acres of land. The total amount represented seven and a half percent of the State of California.

At the beginning of the 1852 California legislative session, the Legislature recognized the value of the land represented in the treaties and appointed committees to prepare joint resolutions and committee reports to recommend how California’s U.S. Senators should proceed regarding the ratification of the treaties. The Special Committee on the Disposal of Public Land summed up the views opposing ratification of the treaties in its report on the public domain:

Your memorialists feel assured, from all the facts which are daily transpiring, and the state of public feeling throughout the mines, that if those treaties are ratified, without any sufficient amendments to alter their permanent disposition of the public domain, it will be utterly impossible to prevent the continued collisions between the miners and the Indians. It will not be owing to any objection of the former to the mining of the Indians in the placers; but it will be caused by the exclusive privileges attempted to be secured for Indians, to the mines always heretofore open to the labors of the white man.

Instead of the treaty provisions, the Special Committee proposed a system of missions for the Indians that included:

- Annuities to be paid in provisions and clothing...a parcel of land to be assigned...sufficient for them to cultivate, and with every laudable means to be used to induce them to do so. Their stock of every description should be protected by law, and have the same privileges of grazing with that of our own. To the Indians, should not be denied the right of hunting,
nor that of digging peaceably in the mines, under the same regulations which we observe.

The Indians who are now residing on private lands, with the consent of the owners, or engaged in cultivating their soil, should not be disturbed in their position. They are already in the best school of civilization... The adoption of this plan would obviate the contemplated permanent disposal of a large portion of our mineral and arable land [to the Indians].

In mid-March 1852, the California Assembly (35 to 6) and Senate (19 to 4) voted to submit resolutions opposing the ratification of the treaties to California’s U.S. Senators.

The President submitted the treaties to the U.S. Senate on June 1, 1852. On June 7, the Senate read the President’s message, and referred the treaties to the Committee on Indian Affairs. The treaties were then considered and rejected by the U.S. Senate in secret session. The treaties did not reappear in the public record until January 18, 1905, after an injunction of secrecy was removed.
Early and Current Fish Protection Laws and California Indians

In 1852, the California Legislature enacted *An Act to prohibit the erection of Weirs, or other obstructions, to the run of Salmon*. The Act prohibited any weir, dam, fence, set or stop net or obstruction to the run of salmon in any river or stream in the State. The Act also provided an important exception for California Indian tribes:

This Act shall not apply to any of the Indian tribes, so as in any manner to preclude them from fishing in accordance with the custom heretofore practiced by them.72 [emphasis added]

The original bill, Senate Bill No. 80 was introduced by Senator Hubbs on March 13, read a first and second time and referred to the Committee on Commerce and Navigation.73 The first version of the original bill made no reference to Indian tribes. However, the Committee recommended the amendment related to Indian tribes that became law.74

The following Table 4 lists some examples of California laws related to fish that have accommodated Indian tribes’ practices in the past and today.

<table>
<thead>
<tr>
<th>Date</th>
<th>Law</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1852</td>
<td>1852 Cal. Stat. ch. 62</td>
<td>An act to prohibit the erection of Weirs, or other obstructions, to the run of Salmon</td>
</tr>
<tr>
<td>1854</td>
<td>1854 Cal. Stat. ch. 70</td>
<td>Amendment to An act to prohibit the erection of Weirs, or other obstructions, to the run of Salmon</td>
</tr>
<tr>
<td>1866</td>
<td>1866 Cal. Stat. ch. 404</td>
<td>An Act for the preservation of trout in the Counties of San Mateo and Santa Clara</td>
</tr>
<tr>
<td>1951</td>
<td>1951 Cal. Stat. ch. 1486</td>
<td>An act to add Section 429.8 to the Fish and Game Code, relating to the taking of fish by members of the Yurok Indian Tribe</td>
</tr>
<tr>
<td>1955</td>
<td>1955 Cal. Stat. ch. 389</td>
<td>An act to add Section 1418 to the Fish and Game Code, relating to hunting and fishing rights of California Indians</td>
</tr>
<tr>
<td>1961</td>
<td>1961 Cal. Stat. ch. 963</td>
<td>An act to amend Section 12300 of the Fish and Game Code, relating to Indians</td>
</tr>
<tr>
<td>2002</td>
<td>CAL FISH &amp; GAME CODE §7155 (1994)</td>
<td>Right of members of Yurok Indian tribe to take fish from Klamath River</td>
</tr>
</tbody>
</table>
California Fish & Game Code §123000 currently provides that:

Irrespective of any other provision of law, the provisions of this code are not applicable to California Indians whose names are inscribed upon the tribal rolls, while on the reservation of such tribe and under those circumstances in this State where the code was not applicable to them immediately prior to the effective date of Public Law 280, Chapter 505, First Session, 1953, 83d of Congress of the United States. No such Indian shall be prosecuted for the violation of any provision of this code occurring in the places and under the circumstances hereinabove referred to. Nothing in this section, however, prohibits or restricts the prosecution of any Indian for the violation of any provision of this code prohibiting the sale of any bird, mammal, fish, or amphibia.
Appendix 1 – Original Bill Material Pertaining to California Statutes, 1850 Chapter 133

This Appendix is based on a review of the enacted laws published in the Statutes of California, First Session of the Legislature, 1849-1850, and the Original Bill File, Chapter 133, 1850, California Secretary of State, State Archives, Location E6553, Box 1. Copies of the original documents and the transcript of the contents of Original Bill File are on file with the California Research Bureau.

The following is a combined comparison of the provisions contained in California Statutes, Chapter 133, Entitled “An Act for the Government and Protection of Indians” and the proposed bills contained in the Original Bill File. The notable differences in enacted law and proposed bill language is described in the annotated footnotes.

- Section 1. Justices of the Peace had jurisdiction in all cases of complaints “by, for, or against Indians.”

- Section 2. Persons or proprietors of lands where Indians resided were to permit the Indians to peaceably and unmolested live “in the pursuit of their usual avocations for the maintenance of themselves and families.” Provided:
  - White persons or proprietors could apply to the Justice of the Peace to “set off to such Indians a certain amount of land…a sufficient amount…for the necessary wants of such Indians, including the site of their village or residence, if they [the Indians] so prefer[red] it.”
  - In no case was “such selection [of land to] be made to the prejudice of such Indians,” nor were the Indians to “be forced to abandon their homes or villages where they…resided for a number of years.”

* Senate Bill No. 54 introduced by Senator Chamberlin, at the request of Senator Bidwell, provided for Justices of the Peace for Indians. These Justices of the Peace were to be elected by the Indians directly, at the order and direction of the Court of Sessions. Pursuant to the language in the bill, the Court of Sessions provided Inspectors of Elections to discharge the same duties as county election inspectors. The bill also provided that the inspectors “procure one or more interpreters to be at the polls during the election who shall ask every Indian who is entitled to vote, whom he prefers for Justice for the Indians the ensuing year, and his vote shall be recorded for the person he prefers.” This language was not contained in the bill proposed by the Assembly, nor the final law enacted in 1850.

† Sections 5 through 7 of Senate Bill 54 contained similar language but gave the issues in this section more comprehensive treatment than what appears in the enacted law. Bill No. 54: 1) permitted Indians “and their descendents” to reside on such lands; 2) defined “usual avocations” as “hunting, fishing, gathering seeds and acorns for the maintainance [sic] of themselves and families;” and 3) stated that “in no case shall [I]ndians be forced to abandon their village sites where they have lived from time immemorial.” Emphasis added.

California Research Bureau, California State Library
Either party feeling aggrieved could appeal the Justice of the Peace’s decision to the County Court.

Section 3. “Any person having or hereafter obtaining a minor Indian, male or female, from the parents or relations of such Indian minor, and wishing to keep it…shall go before a Justice of the Peace in his Township, with the parents or friends of the child, and if the Justice of the Peace becomes satisfied that no compulsory means have been used to obtain the child from its parents or friends, shall enter on record, in a book kept for that purpose, the sex and probable age of the child, and shall give to such person a certificate, authorizing him or her to have the care, custody, control and earnings of such minor; until he or she obtain the age of majority. Every male Indian shall be deemed to have attained his majority at eighteen, and the female at fifteen years.” (Original text with emphasis added)

Section 4. A person that neglected to “clothe or suitably feed…or inhumanly” treated a minor Indian in his care, could be fined not less than ten dollars, if convicted. The Justice of the Peace could place the minor Indian “in the care of some other person, giving him the same rights and liabilities that the former master…was entitled and subject to.”

Section 5. “Any person wishing to hire an Indian [had to] go before the Justice of the Peace with the Indian and make such contract as the Justice may approve.” The Justice filed the written contract in his office. The contract was binding between the parties; “but no contract between a white man and an Indian, for labor [was] otherwise…obligatory on the part of the Indian.”

Section 6. Indians or white persons could make complaints before a Justice of the Peace. However, “in no case [could] a white man be convicted of any offen[s]e upon the testimony of an Indian, or Indians.”

Section 7. Any person convicted of forcibly “conveying” an Indian from his home or compelling an Indian to work against his will, would be fined at least fifty dollars.

---

1 The original Assembly Bill 129 defined the age of majority for a male Indian at twenty years, and for a female at seventeen years, but was lined out and changed to the ages contained in Section 9 of Senate Bill 54. Also, Section 8 of Senate Bill 54 mandated that the “name (if any) given by the person taking the child” was also to be included in the Justice of the Peace’s record book. This language is absent from any version of the Assembly bill or the law.

2 Section 12 of Senate Bill 54 made the fine to be not less than 50 nor more than 200 hundred dollars. This section also provided that the minor Indian could “return to his or her parents or relatives,” language absent from the enacted law.

3 This section is absent from Senate Bill 54.
Sections 8 and 18. Justices of the Peace were required every six months to report all moneys and fines collected to the county Court of Sessions and pay them over to the Treasurer, who was to keep the monies in an “Indian fund.”

Sections 9. Justices of the Peace were to “instruct the Indians in their neighborhood in the laws which related to them.” Any tribes or villages refusing or neglecting to obey the laws could be reasonably chastised.

Section 10. Any person was subject to fine or punishment if they set the prairie on fire, or refused “to use proper exertions to extinguish the fire.”

Sections 11 – 13. If an Indian committed “an unlawful offen[s]e against a white person,” the person offended was not allowed to mete out the punishment. However, the offended white person could, without process, bring the Indian before the Justice of the Peace, and on conviction the Indian was punished according to provisions in the Act. Justices could require “chiefs and influential men of any village to apprehend and bring before them any Indian charged or suspected of an offen[s]e.”

Section 14. If a convicted Indian was punished by paying a fine, any white person, with the consent of the Justice, could give bond for the Indian’s fine and costs. In return, the Indian was “compelled to work until his fine was discharged or cancelled. The person bailing was supposed to “treat the Indian humanely, and clothe and feed him properly.” The Court decided “the allowance given for such labor.”

Section 15. Anyone convicted of providing intoxicating liquors to an Indian was fined not less than 20 dollars.

Sections 16-17. An Indian convicted of stealing horse, mules, cattle or “any valuable thing,” could receive 25 lashes with a whip or be fined up to 200 dollars. The punishment was at the discretion of the Court or a jury. The Justice could appoint a white man or an Indian to whip the Indian, but was not to permit “unnecessary cruelty” in executing the sentence.

Section 19. If a white person made an application to a Justice of the Peace for confirmation of a “contract with or in relation to an Indian,” had to pay two dollars per each contract determination.

* The original language of this section was changed from “Indian” to “any person” in the final version of AB 129.
Section 20. Any Indian able to work and support himself in some honest calling, not having wherewithal to maintain himself, who shall be found loitering and strolling about, or frequenting public places where liquors are sold, begging, or leading an immoral or profligate course of life, shall be liable to be arrested on the complaint of any resident citizen of the county, and brought before any Justice of the Peace of the proper county, Mayor or Recorder of any incorporated town or city, who shall examine said accused Indian, and hear the testimony in relation thereto, and if said Justice, Mayor, or Recorder shall be satisfied that he is a vagrant...he shall make out a warrant under his hand and seal, authorizing and requiring the officer having him in charge or custody, to hire out such vagrant within twenty-four hours to the best bidder, by public notice given as he shall direct, for the highest price that can be had, for any term not exceeding four months; and such vagrant shall be subject to and governed by the provisions of this Act, regulating guardians and minors, during the time which he has been so hired. The money received for his hire, shall, after deducting the costs, and the necessary expense for clothing for said Indian, which may have been purchased by his employer, be, if he be without a family, paid into the County Treasury, to the credit of the Indian fund. But if he have a family, the same shall be appropriated for their use and benefit: Provided, that any such vagrant, when arrested, and before judgment, may relieve himself by giving to such Justice, May, or Recorder, a bond, with good security, conditioned that he will, for the next twelve months, conduct himself with good behavior, and betake to some honest employment for support.
Appendix 2 - Original Bill Material Pertaining to California Statutes 1860, Chapter 231

This Appendix contains a verbatim transcription of the Original Bill Materials, located in the California State Archives, that are related to the 1860 amendment of the Act for the Government and Protection of Indians passed April 22, 1850. The first document is the initial Assembly Bill No. 65 introduced for consideration on January 19, 1860. The second document is a “substitute” Assembly Bill No. 65, introduced for consideration on February 17, 1860. The third document is the engrossed bill that was enrolled on April 6, 1860.

The first page of each transcribed document in this Appendix contains the legislative history of the bill. This information is handwritten and originally signed by each legislative officer on the front page of the original documents. The language originally contained in the proposed bills, but subsequently deleted from the text during the course of the legislative process is noted in brackets.
Assembly Bill No. 65

An act amendatory of an act entitled an act for the Government and Protection of Indians passed April 22, 1850

In Assembly January 19, 1860
Read first & second time
Referred to Com. on Indian Affairs

Weston
Asst Clerk

February 11, 1860, Reported with amendt & passage
Recommended as amended

Weston
Asst Ckl

Feb. 13, 1860
Taken from file
& referred to Jud[iciary] Com[mittee]

Weston
Asst Ckl

Feb 17, 1860, Substitute reported & recommended

Weston
Asst Ckl

Feb 27, 1860: Substituted adopted & ordered printed

Weston
Ass’t Ckl
An Act amendatory of an act entitled An Act for the Government and Protection of Indians passed April 22, 1850

The People of the State of California represented in Senate and Assembly do enact as follows:

Section 1st, Section third of said Act is hereby amended so as to read as follows

Sec. 3d Any person having or hereafter obtaining any Indian child or children male or female from the parents or relations of such child or children [stricken from text: with their] and wishing to domesticate said child or children and any person desiring to obtain any Indian or Indians either children or grown persons that may have been taken prisoner or prisoners [stricken from text: and wishing to domesticate either children or grown persons in any expedit] of war [stricken from text: in any] and wishing to domesticate said Indians, such person shall go before a Justice of the Peace of the County in which such Indians may [stricken from text: be] reside at the time and if the Justice of the Peace becomes satisfied that no compulsory means have been used to obtain the said child or children from its parents or friends or that the said child or children or other Indian or indians of either sex have been taken and are held as a prisoner or prisoners of war, he shall enter on record, in a book kept for that purpose the sex and probable age of the child or children or other indians, and shall give to such person a certificate authorizing him or her to have the care custody control and earnings of such child or children or other Indians, for and during the following term of years, such children as are under twelve years of age, until they attain the age of twenty five years, such children as are over twelve and under eighteen years of age until they attain the age of thirty years, and such indians as may be over the age of eighteen years, for and during the term of ten years then next following the date of said certificate, any person or persons [stricken: being] having any indian or indians in his or their possession as such prisoners shall have the preference to domesticate as many of such indians as he or they may desire for their own use, every indian either male or female in the possession or under the control of any person under the provisions of this act shall be taken and deemed to be a minor Indian, [stricken from text: for such]

Sec. 2nd Section seventh of said act is hereby amended so as to read as follows,

Sec 7. If any person shall forcibly convey any Indian from any place without this State to any place within this State, or from his or her home within this State, or compel him, or her, to work or perform any services against his or her will,

Except as provided in this act, he or they may be upon conviction fined in any sum not less than fifty dollars, nor more than five hundred dollars, at the discretion of the Court

[First Document Transcription Ends Here]
Substitute for Assembly Bill No. 65

An act amendatory of an act entitled An Act for the Government & Protection of Indians passed April 22, 1850

Feb 17, 1860. Reported as substitute for Assembly Bill No. 65 & passage recommended

Weston
Ass’t Clk

Feb. 27, 1860, adopted & ordered printed.

Weston
Ass’t Clk

Mch 10, 1860, amended, ___ suspended, considered engrossed read third time and passed

Weston
Asst Clk

Judiciary Committee
An Act amendatory of An Act Entitled “An Act for the Government and Protection of Indians passed April 22, 1850

The People of the State of California represented in Senate and Assembly, do enact as follows:

Section 1st. Section third of said Act is hereby amended so as to read as follows:

Section 3: County and District Judges in the respective counties of this State shall by virtue of this Act have full power and authority, at the instance and request of any person having or hereafter obtaining any Indian child or children male or female under the age of fifteen years from the parents or person or persons having the care or charge of such child or children with the consent of such parents or person or persons having the care or charge of any such child or children, or at the instance and request of any person desirous of obtaining any Indian or Indians whether children or grown persons that may be held as prisoners of war, or at the instance and request of any person desirous of obtaining any vagrant Indian or Indians as have no settled habitation or means of livelihood and have not placed themselves under the protection of any white person, to bind and put out such Indians as apprentices to trades --- husbandry or other employments as shall to them appear proper, and for this purpose shall execute duplicate Articles of Indenture of Apprenticeship on behalf of such Indians, which Indentures shall also be executed by the person to whom such Indian or Indians are to be indentured: one copy of which shall be filed by the County Judge [stricken from text: with the] in the Recorders Office of the County and one copy retained by the person to whom such Indian or Indians may be indentured; such Indenture shall authorise [sic] such person to have the care custody control and earnings of such Indian or Indians and shall require such person to clothe and suitably provide the necessaries of life, for such Indian or Indians for and during the term for which such Indian or Indians shall be apprenticed, and shall contain the sex name and probable age of such Indian or Indians, Such Indentures may be for the following terms of years, such children as are under fourteen years of age, if males until they attain the age of twenty five years; if females until they attain the age of twenty one years; such as are over fourteen and under twenty years of age if males until they attain the age of thirty years; if females until they attain the age of twenty five years; and such Indians as may be over the age of twenty years for and during the term of ten years then next following the date of such Indenture at the discretion of such Judge. Such Indians as may be indentured under the provisions of this section shall be deemed within such provisions of this act as are applicable to minor Indians

Section 2d. Section seventh of said act is hereby amended so as to read as follows:

Section 7. If any person shall forcibly convey any Indian from any place without this State to any place within this State or from his or her home within this State, or compel him or her to work or perform any service against his or her will except as provided in
this Act he or they shall upon conviction thereof be fined in any sum not less than one
hundred dollars nor more than five hundred dollars before any court having jurisdiction at
the discretion of the Court, and the collection of such fine shall be enforced as provided
by law in other criminal cases, one half to be paid to the prosecutor and one have [sic] to
the County in which such conviction is had.

[Second Document Transcription Ends Here]
Substitute for Assembly Bill No. 65

An act amendatory of an act entitled an act for the government & protection of Indians passed April 22, 1850

Feb 17, 1860 reported as substitute for assembly Bill No. 65 & passage recommended

Weston
Asst Clk

Feb 27, 1860, adopted and ordered printed

Weston
Asst. Clk

March 10, 1860 Amended rules suspended, considered
Engrossed read third time and passed

Weston
Asst Clk

E.W. Casey Engrossing Clerk
231 [in pencil]

Judiciary Committee

March 13th 1860
Read first and second times and refd to the Committee on Federal Relations

Williamson
Asst Secty

March 23rd 1860
Reported back and passage recommended & placed on file April 6th
Taken up read a third time & passed

Enrolled April 6th 1860
H.C. Kibbe
Enrolling Clerk
Chap 231 [in pencil]


The People of the State of California represented in Senate and Assembly do enact as follows.

Section 1. Section third of said Act, is hereby amended so as to read as follows;

Section 3d. County and District Judges in the respective Counties of the State shall by virtue of this act have full power and authority, at the instance and request of any person having or hereafter obtaining any Indian child or children male or female under the age of fifteen years, from the parents or person or persons having the care or charge of such child or children with the consent of such parents or person or persons having the care or charge of any such child or children, or at the instance and request of any person desirous of obtaining any Indian or Indians, whether children or grown persons that may be held as prisoners of war, or at the instance and request of any person desirous of obtaining any vagrant Indian or Indians as have no settled habitation or means of livelihood, and have not placed themselves under the protection of any white person, to bind and put out such Indians as apprentices to trades husbandry or other employments as shall to them appear proper, and for this purpose shall execute duplicate Articles of Indenture of Apprenticeship on behalf of such Indians, which Indentures shall also be executed by the person to whom such Indian or Indians are to be Indentured; one copy of which shall be filed by the County Judge, in the Recorders office of the County, and one copy retained by the person to whom such Indian or Indians may be Indentured, such Indentures shall authorize such person to have the care custody control and earnings of such Indian or Indians and shall require such person to clothe and suitably provide the necessaries of life for such Indian or Indians, for and during the term for which such Indian or Indians shall be apprenticed, and shall contain the sex name and probable age of such Indian or Indians, such indentures may be for the following terms of years; such children as are under fourteen years of age, if males until they attain the age of twenty five years; if females until they attain the age of twenty one years; such as are over fourteen and under twenty years of age, if males until they attain the age of thirty years; if females until they attain the age of twenty five years, and such Indians as may be over the age of twenty years for and during the term of ten years thru next following the date of such indenture at the discretion of such Judge, such Indians as may be indentured under the provisions of this Section, shall be deemed within such provisions of this Act, as are applicable to minor Indians.
Section 2. Section Seventh of said act is hereby amended so as to read as follows:

Section 7. If any person shall forcibly convey any Indian from any place without this State, to any place within this State, or from his or her home within this State, or compel him or her to work or perform any service against his or her will except as provided in this act, he or they shall upon conviction thereof, be fined in any sum, not less than one hundred dollars nor more than five hundred dollars, before any Court having jurisdiction at the discretion of the Court, and the collection of such fine shall be enforced as provided by law in other criminal cases, on half to be paid to the prosecutor, and one half to the County in which such conviction is had.

[Third Document Transcription Ends Here]

California Secretary of State, California State Archives
Original Bill File AB 65 1860
Location: E6562 Box 1

Transcribed July 29, 2002 by Kimberly Johnston Dodds, California Research Bureau
Appendix 3 - Court of Sessions

The Courts of Sessions were the earliest county-level courts of record* that adjudicated criminal offenses. The first Courts of Sessions in California were authorized by the state Constitution:

There shall be elected in each of the organized counties of this State, one County Judge, who shall hold his office for four years... The County Judge, with two Justices of the Peace, to be designated according to law, shall hold Courts of Sessions with such criminal jurisdiction as the Legislature shall prescribe, and he shall perform such other duties as shall be required by law. 75

The two Justices of the Peace (Associate Justices of the Courts of Sessions) were chosen by all of the Justices of the Peace from within the county. 76

The Legislature conferred upon the Courts of Sessions jurisdiction over “all cases of assault, assault and battery, breach of the peace, riot, affray, and petit larceny, and over all misdemeanors punishable by fine not exceeding five hundred dollars, or imprisonment not exceeding three months, or both such fine and imprisonment.” 77 The jurisdiction of the Courts of Sessions also extended to grand jury investigations of public offenses committed or triable in their respective counties, except murder, manslaughter, arson and other crimes that were punished by death. These courts also heard and decided appeals from lower courts that were not courts of record -- the justices’, recorders’, and mayors’ courts. The Courts of Sessions did not have jurisdiction to try indictments against justices of the peace. 78

In counties that did not have a board of supervisors, the Courts of Sessions also had the following powers to:

- Make orders and decisions respecting county property, including care and preservation;
- Examine, settle and allow all accounts legally chargeable against the county;
- Direct assessing the value of real and personal property taxes;
- Examine and audit accounts of all county officers;
- Control and manage public roads, turnpikes, ferries, canals, and bridges within the county;

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* A court of record is a court whose proceedings are recorded in some manner of permanence at the same time that the proceedings take place. See Cal Jur vol. 16, part 1 3d ed. (San Francisco: Bancroft-Whitney Co. 1983, 2002 supp.) 300-301.
Divide the county into townships, including changing township boundaries when required; and

Establish and change election precincts.79

In 1863, the Legislature abolished the Courts of Sessions. The County Courts then maintained similar jurisdiction as the Courts of Sessions.80
Appendix 4 – 1861 Indian Article of Indenture

Feb 4, 1861

SACRAMENTO DAILY UNION, MONDAY,
as we can gather, was to apprise them by virtue of their rights as constituents of the Indian tribes of the perils of the Indian, causing the Indians to be made out to be mere, Geiger & Times, as private individuals, engaged in the ranching business.

The law of last year was passed under a high-pressure policy, no doubt for the special accommodation of the various parties interested in Indian war claims and Indian embroilments, who besought the Legislature. It provides for a County and District Judges to apprehend Indians, both children and adults, at the instigation of any party having property in charge, parties desiring to take up vacant lands, on the bond or security that they shall promise to sell all stock in trade and sell them during their term of their apprenticeship. The Act authorizes the Indian Commissioner to take care of the Indians, and Geiger & Co. do not appear to have been over careful in complying with the terms of the law, as the provisions have not been observed. The Indians under the age of twenty are apprenticed for the full term of the apprenticeship, which is contrary to the regulations contained within the Act of April, 1853.

The times are propitious for a change in the Indian law "for the government and protection of Indians"—a change which shall deprive the parties of the above transaction, and others who have sought to obtain control of the persons of Indians under similar circumstances, of the unlimited power they hold under the Act of last year. The new Act is now in his place, and the legislatures of 1854 are materially in the composition from the one of the year preceding. At all events, let us have an investigation of the matter brought to notice in another column, and a little to the left, be obtained, on the general question of the law under which parties are seeking to establish a system of domestic service in our midst.

A SEVING MAN, A SEVING WOMAN.

Speech of Z. Montgomery.—The Marysville Express publishes the speech of Z. Montgomery, made recently in the Assembly on the subject of the Broderick engaging resolutions, and the notes of the House adjourned. 1854.
Tribal History and Consultation

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SACRAMENTO DAILY UNION, MONDAY, FEBRUARY 1, 1861

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Tribal History and Consultation

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California Water Plan Update 2005

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California Water Plan Update 2005

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Early California Laws and Policies... Volume 4

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Endnotes

1 To my knowledge, either scholars, or the State of California, have never published an exhaustive and complete review of primary sources or thorough compilation related to this subject.

2 Given the scope of the research, a review of secondary historical sources was first conducted. Based upon this research, a number of primary and original State of California legislative and executive documents were analyzed, mainly from the period of 1850 to 1865. I also examined certain primary sources of federal documents related to California Indian Affairs during the same time period and contained in the same collections. The primary documents and sources reviewed for this report are located at the California State Archives, California State Library, Sacramento Archives and Museum Collection Center, and the Bancroft Library at the University of California, Berkeley. The secondary sources are located in the California State Library and University of California library collections.


6 Original Bill File, Chapter 133, 1850, California Secretary of State, State Archives, Location E6553, Box 1, (transcript of Original Bill File contents on file with the California Research Bureau); *Journal of the Senate of the State of California, at the First Session of the Legislature, 1849-1850*, (San José: J. Winchester, State Printer, 1850) 217, 224 (Senate Journal – 1850).

7 Original Bill File Chapter 133, 1850.

8 Original Assembly Bill No. 129, Original Bill File Chapter 133, 1850; *Senate Journal – 1850*, 367, 386-387.


13 1850 Cal. Stat. ch. 73 §§ 1-3.

14 Ibid.


18 Original Bill File, Chapter 133, 1850.


20 Ibid.
21 1855 Cal. Stat. ch. 144.
23 Original Bill File, Chapter 231, 1860, Secretary of State, California State Archives.
25 *In the Matter of The Indian Boy Frank, Petition of L. Harris for Apprenticeship*, filed January 28, 1862; 
*William Moorhead to Hon. Robert Robinson, Petition for Apprentice*, filed March 4, 1862, in the 
Sacramento Archives and Museum Collection Center, Sacramento County Archives, County Court: Indian 
Indentures, 80/132/20-21: 32:42. Copies of originals and related transcripts are on file with the California 
Research Bureau.
26 *William Moorhead to Hon. Robert Robinson, Petition for Apprentice*, filed March 4, 1862, Sacramento 
County Archives, County Court: Indian Indentures, 80/132/20-21: 32:42.
27 Ibid.
28 Robert F. Heizer and Alan F. Almquist, *The Other Californians: Prejudice and Discrimination under 
Spain, Mexico and the United States to 1920* (Berkeley: University of California Press, 1971), 53.
29 Heizer and Almquist, 51-57.
30 “Lo, the Poor Indian,” *Alta California*, April 7, 1855, 2-1.
31 *San Francisco Herald*, December 14, 1856, 4-1.
32 “Indian Slavery,” *Alta California*, April 14, 1862, 1.
34 Francis P. Farquhar, ed. *Up and Down California in 1860-1864: The Journal of William H. Brewer* 
35 Jesse B. Hart, *A Treatise on the Practice of the Courts of the State of California, Carefully Adapted to 
40 1855 Cal. Stat. ch 165 § 1.
41 1855 Cal. Stat. ch 175 §§ 3-5.
43 Peter H. Burnett, “Governor’s Annual Message to the Legislature, January 7, 1851,” in *Journals of the 
Senate and Assembly of the State of California, at the Second Session of the Legislature, 1851-1852*, (San 
44 CAL. CONST. of 1850, Art. VII, § 3.
45 Peter H. Burnett, “Governor’s Annual Message to the Legislature, January 7, 1851,” in *Journals of the 
Senate and Assembly of the State of California, at the Second Session of the Legislature, 1851-1852*, (San 
46 Ibid., 16-17.
47 Ibid., 18.
48 Ibid.
49 ROOT CELLAR, Sacramento Genealogical Society, California State Militia: Index to the Muster Rolls of 1851 to 1866 (Sacramento: The Society, 1999), ii, 1396-1465.
50 Ibid., 1432-1446.
51 Ibid., ii.
52 1850 Cal. Stat. ch. 54.
53 1850 Cal. Stat. ch. 76.
54 1850 Cal. Stat. ch. 54, §§ 1, 7, 17, 20.
56 1850 Cal. Stat. ch. 76, §§ 6, 8, 10, 45, 56, 57.
58 “Majority Report of the Special Joint Committee on the Mendocino War,” in Appendix to Journals of the Senate, of the Eleventh Session of the Legislature of the State of California, (Sacramento: C.T. Botts, State Printer, 1860), 4-6.
59 Ibid., 7.
61 Ibid.
62 Ibid.
66 Ellison, 186.
69 Ibid., 590-591.
71 Ellison, 193, citing Congressional Globe, 32 Cong., 1 Sess, Part III, 2103; and Congressional Record, 58 Cong., 3 Sess. Part I, 1021.


74 Original Bill File, Chapter 62, 1852.

75 CAL. CONST. of 1850, Art. VI, § 8.


77 1850 Cal. Stat. ch. 86 § 5.


79 Ibid.

Tribal Consultation Guidelines, Supplement to General Plan Guidelines
By Governor’s Office of Planning and Research
STATE OF CALIFORNIA

Tribal Consultation Guidelines

SUPPLEMENT TO GENERAL PLAN GUIDELINES

April 15, 2005

GOVERNOR’S OFFICE OF PLANNING AND RESEARCH
Director’s Message

April 15, 2005

The Governor’s Office of Planning and Research (OPR) is proud to announce the publication of the 2005 Supplement to the General Plan Guidelines. The 2005 Supplement (also known as Tribal Consultation Guidelines) provides advisory guidance to cities and counties on the process for consulting with Native American Indian tribes during the adoption or amendment of local general plans or specific plans, in accordance with the statutory requirements of Senate Bill 18 (Chapter 905, Statutes of 2004). At a future date, this 2005 Supplement will be incorporated into the General Plan Guidelines as a new chapter on tribal consultation. It is our hope that this 2005 Supplement will be useful not only to city and county planning staffs for complying with the new statutory mandates, but also to local elected officials, planning consultants, landowners, and tribal members who are involved in the general plan process.

In all of its work, OPR attempts to encourage more collaborative and comprehensive land use planning at the local, regional, and statewide levels. These goals are consistent with the goals of Senate Bill 18, which for the first time in the nation, requires cities and counties to consult with Native American tribes when adopting and amending their general plans or specific plans.

The completion of this 2005 Supplement would not have been possible without the advice and assistance of many organizations and individuals, whose support OPR acknowledges and appreciates. These organizations and individuals include the Native American Heritage Commission and its staff, the members and representatives of numerous California Native American tribes, many city and county governments, state agency representatives, professional associations and academic institutions. We appreciate their assistance in preparing this 2005 Supplement, including participation at several meetings and public workshops.

OPR met the statutory deadline of March 1, 2005, to publish these guidelines by issuing interim guidelines on March 1. In developing the interim guidelines, OPR consulted with a wide range of stakeholders and experts. We consulted with city and county representatives (planners, legislative staff and legal counsels); tribal representatives and associations; staff of the Native American Heritage Commission (NAHC), including attendance at two NAHC commission meetings; federal agencies with experience in tribal consultation; academic institutions; and professional associations that deal with archaeological and cultural resource protection. In addition, we consulted with numerous tribal liaisons within state government and sought the input of the League of California Cities and the California State Association of Counties.
Based upon this consultation, OPR issued Draft Tribal Consultation Guidelines on February 22, 2005 for public review and comment. OPR conducted a public workshop on February 25, 2005, which was well attended and resulted in a productive discussion of the process envisioned by SB 18, as well as many specific recommendations for improvements to the 2005 Supplement.

In response to requests from many parties for additional time to consult with OPR regarding the 2005 Supplement, OPR continued to reach out to stakeholders for an additional 45 days to ensure that their interests were heard. Between March 1 and April 15, OPR held four meetings throughout the State to receive additional comments. The meetings were held in Klamath, Corning, Sonora, and Temecula. This April 15 edition of the guidelines reflects the comments and concerns expressed at those four meetings, as well as written comments received by OPR.

We hope that you will find this 2005 Supplement to be an informative guide and a useful tool in the practice of local planning. I invite your suggestions on ways to improve OPR’s General Plan Guidelines and this 2005 Supplement, as OPR continues to refine and update all of its guidance to city and county planning agencies.

Sean Walsh
Director, OPR
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Part A
SB 18 Context and Basic Requirements

Sections I through III of the 2005 Supplement provide background information to familiarize local government agencies with the intent of Senate Bill 18 (Burton, Chapter 905, Statutes of 2004) and the importance of protecting California Native American traditional tribal cultural places. Local governments will be better prepared to enter into consultations with tribes if they have a basic knowledge of tribal concerns and the value of cultural places to tribes. The key provisions of SB 18 are also outlined in table and text form.

1. Introduction

This 2005 Supplement to the 2003 General Plan Guidelines addresses the requirements of SB 18, authored by Senator John Burton and signed into law by Governor Arnold Schwarzenegger in September 2004. SB 18 requires local (city and county) governments to consult with California Native American tribes to aid in the protection of traditional tribal cultural places (“cultural places”) through local land use planning. SB 18 also requires the Governor’s Office of Planning and Research (OPR) to include in the General Plan Guidelines advice to local governments for how to conduct these consultations.

The intent of SB 18 is to provide California Native American tribes an opportunity to participate in local land use decisions at an early planning stage, for the purpose of protecting, or mitigating impacts to, cultural places. The purpose of involving tribes at these early planning stages is to allow consideration of cultural places in the context of broad local land use policy, before individual site-specific, project-level land use decisions are made by a local government.

SB 18 requires local governments to consult with tribes prior to making certain planning decisions and to provide notice to tribes at certain key points in the planning process. These consultation and notice requirements apply to adoption and amendment of both general plans (defined in Government Code §65300 et seq.) and specific plans (defined in Government Code §65450 et seq.). Although SB 18 does not specifically mention consultation or notice requirements for adoption or amendment of specific plans, existing state planning law requires local governments to use the same processes for adoption and amendment of specific plans as for general plans (see Government Code §65453). Therefore, where SB 18 requires consultation and/or notice for a general plan adoption or amendment, the requirement extends also to a specific plan adoption or amendment. Although the new law took effect on January 1, 2005, several of its provisions regarding tribal consultation and notice did not take effect until March 1, 2005.

The General Plan Guidelines is an advisory document that explains California legal requirements for general plans. The General Plan Guidelines closely adheres to statute and case law. It also relies upon commonly accepted principles of contemporary planning practice.

1 California Government Code §65040.2
When the words “shall” or “must” are used, they represent a statutory or other legal requirement. “May” and “should” are used when there is no such requirement. The 2005 Supplement:

- Provides background information regarding California Native American cultural places and tribes.
- Outlines the basic requirements of SB 18.
- Provides step-by-step guidance to local governments on how and when to consult with tribes.
- Offers advice to help local governments effectively engage in consultation with tribes.
- Provides information about preserving, or mitigating impacts to, cultural places.
- Discusses methods to protect confidentiality of information regarding cultural places.
- Presents ways of encouraging voluntary landowner involvement in the preservation of cultural places.

II. Background Information

The principal objective of SB 18 is to preserve and protect cultural places of California Native Americans. SB 18 is unique in that it requires local governments to involve California Native Americans in early stages of land use planning, extends to both public and private lands, and includes both federally recognized and non-federally recognized tribes. This section provides an overview of California Native American cultural places and California Native Americans.

**California Native American Cultural Places**

SB 18 refers to Public Resources Code §5097.9 and 5097.995 to define cultural places:

2. Native American sanctified cemetery, place of worship, religious or ceremonial site, or sacred shrine (Public Resources Code §5097.9).

3. Native American historic, cultural, or sacred site, that is listed or may be eligible for listing in the California Register of Historic Resources pursuant to Section 5024.1, including any historic or prehistoric ruins, any burial ground, any archaeological or historic site (Public Resources Code §5097.995).

These definitions can be inclusive of a variety of places. Archaeological or historic sites may include places of tribal habitation and activity, in addition to burial grounds or cemeteries. Some examples are village sites and sites with evidence (artifacts) of economic, artistic, or other cultural activity. Religious or ceremonial sites and sacred shrines may include places associated with creation stories or other significant spiritual history, as well as modern day places of worship. Collection or gathering sites are specific places where California Native Americans access certain plants for food, medicine, clothing, ceremonial objects, basket making, and other

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2 Due to a drafting error, SB 18 contains multiple references to Public Resources Code (PRC) §5097.995 which is no longer in existence. In 2004, PRC §5097.995 was amended and renumbered to PRC §5097.993 by Senate Bill 1264 (Chapter 286). Local governments should refer to PRC §5097.993 when looking for PRC §5097.995.

3 Ibid.
crafts and uses important to on-going cultural traditions and identities; these places may qualify as religious or ceremonial sites as well as sites that are listed or eligible for listing in the California Register of Historic Resources.

Native American cultural places are located throughout California because California Native American people from hundreds of different tribes made these lands their home for thousands of years. Due to the forced relocation of tribes by the Spanish, Mexicans, and Americans, most tribes do not currently control or occupy the lands on which many of their cultural places are located. As a result, California Native Americans have limited ability to maintain, protect, and access many of their cultural places.

A number of federal and state laws have been enacted to preserve cultural resources and have enabled some Native American tribes to promote the preservation and protection of their cultural places. The National Historic Preservation Act (NHPA), which established historic preservation as a national policy in 1966, includes a Section 106 review process that requires consultation to mitigate damage to “historic properties” (defined per 36 CFR 800.16(1) as places that qualify for the National Register of Historic Places), including Native American traditional cultural places (TCPs, as described in National Register Bulletin 38) whenever any agency directs a project, activity or program using any federal funds or requiring a federal permit, license or approval (36CFR800.16). The National Environmental Policy Act (NEPA) requires every federal project to include in an Environmental Impact Statement documentation of environmental concerns, including effects on important historic, cultural, and natural aspects of our national heritage. Presidential Executive Order 13007, “Indian Sacred Sites,” ensures that federal agencies are as responsive as possible to the concerns of Native American tribes regarding their cultural places. The Archaeological Resources Protection Act (ARPA) makes desecration of Native American cultural places on federal lands a felony.

California state law includes a variety of provisions that promote the protection and preservation of Native American cultural places. A number of these provisions address intentional desecration or destruction of cultural places and define certain of such acts as misdemeanors or felonies punishable by both fines and imprisonment. These include the Native American Historic Resource Protection Act (PRC §5097.995-5097.9964), Public Resources Code §5097.99, Penal Code §622.5 and Health and Safety Code §7050.5, §7052. Other provisions require consideration of potential impacts of planned projects on cultural resources, which may include Native American cultural places. Public Resources Code 5097.2 requires archaeological surveys to determine the potential impact that any major public works project on state land may have on archaeological resources. The California Environmental Quality Act (CEQA) requires project lead agencies to consider impacts, and potential mitigation of impacts, to unique archaeological and historical resources.5 California Executive Order W-26-92 affirms that all state agencies shall recognize and, to the extent possible, preserve and maintain the significant heritage resources of the State. Public Resources Code §5097.9, which mandates noninterference of free expression or exercise of Native American religion on public lands, promotes preservation of certain Native American cultural places by ensuring tribal access to these places.

4 Ibid.
5 CEQA Statutes at Public Resources Code §21083.2-21084.1; CEQA Guidelines at 14 CCR 15064.5-15360.
While these and other laws permit Native Americans to have some say in how impacts to cultural places could be avoided or mitigated, the laws rarely result in Native American input at early stages of land use planning. Generally, these laws provide protection only to those sites located on public or Native American trust lands and address only the concerns of Native Americans who belong to federally recognized tribes, with no official responsibility to non-federally recognized tribes. The intent of SB 18 is to provide all California Native American tribes, as identified by the NAHC, an opportunity to consult with local governments for the purpose of preserving and protecting their cultural places.

**California Native American Tribes**

SB 18 uses the term, California Native American tribe, and defines this term as “a federally recognized California Native American tribe or a non-federally recognized California Native American tribe that is on the contact list maintained by the Native American Heritage Commission” (NAHC). “Federal recognition” is a legal distinction that applies to a tribe’s rights to a government-to-government relationship with the federal government and eligibility for federal programs. All California Native American tribes, whether officially recognized by the federal government or not, represent distinct and independent governmental entities with specific cultural beliefs and traditions and unique connections to areas of California that are their ancestral homelands. SB 18 recognizes that protection of traditional tribal cultural places is important to all tribes, whether federally recognized or not, and it provides all California Native American tribes with the opportunity to participate in consultation with city and county governments for this purpose. As used in this document, the term “tribe(s)” refers to a California Native American tribe(s).

California has the largest number of tribes and the largest Native American population of any state in the contiguous United States. California is home to 109 federally recognized tribes and several dozen non-federally recognized tribes. According to a 2004 California Department of Finance estimate, the Native American population in California is 383,197.

Tribal governments throughout California vary in organizational forms and size. Some tribes use the government form established under the Indian Reorganization Act of 1934 (25CFR81) with an adopted constitution and bylaws. Other tribes have adopted constitutions and bylaws that incorporate traditional values in governing tribal affairs. Many tribal governments are comprised of a decision making body of elected officials (tribal governing body) with an elected or designated tribal leader. Some tribes use lineal descent as the means of identifying the tribe’s leader. In general, tribal governing bodies and leaders serve for limited terms and are elected or designated by members of the tribe. Tribal governments control tribal assets, laws/regulations, membership, and land management decisions that affect the tribe.
III. Basic Requirements of SB 18

This section provides a brief summary of the statutory requirements of SB 18. Later sections of the Supplement provide additional detail regarding these requirements and offer advice to local governments on how to fulfill the notification and consultation requirements of SB 18. (Please refer to Section IV and Section V of these guidelines for additional information regarding the responsibilities outlined below.)

Responsibilities of OPR

Government Code §65040.2(g) requires the Governor’s Office of Planning and Research (OPR) to amend the General Plan Guidelines to contain advice to local governments on the following:

- Consulting with tribes on the preservation of, or the mitigation of impacts to, cultural places.
- Procedures for identifying through the Native American Heritage Commission (NAHC) the appropriate California Native American tribes with whom to consult.
- Procedures for continuing to protect the confidentiality of information concerning the specific identity, location, character, and use of cultural places.
- Procedures to facilitate voluntary landowner participation to preserve and protect the specific identity, location, character, and use of cultural places.

Responsibilities of Local Governments

SB 18 established responsibilities for local governments to contact, provide notice to, refer plans to, and consult with tribes. The provisions of SB 18 apply only to city and county governments and not to other public agencies. The following list briefly identifies the contact and notification responsibilities of local governments, in sequential order of their occurrence.

Prior to the adoption or any amendment of a general plan or specific plan, a local government must notify the appropriate tribes (on the contact list maintained by the NAHC) of the opportunity to conduct consultations for the purpose of preserving, or mitigating impacts to, cultural places located on land within the local government’s jurisdiction that is affected by the proposed plan adoption or amendment. Tribes have 90 days from the date on which they receive notification to request consultation, unless a shorter timeframe has been agreed to by the tribe (Government Code §65352.3).6

Prior to the adoption or substantial amendment of a general plan or specific plan, a local government must refer the proposed action to those tribes that are on the NAHC contact list and have traditional lands located within the city or county’s jurisdiction. The referral must allow a 45 day comment period (Government Code §65352). Notice must be sent

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6 SB 18 added this new provision to state planning law. It applies to any amendment or adoption of a general plan or specific plan, regardless of the type or nature of the amendment. Adoption or amendment of a local coastal program by a city or county constitutes a general plan amendment.
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regardless of whether prior consultation has taken place. Such notice does not initiate a new consultation process.\(^7\)

Local governments must send notice of a public hearing, at least 10 days prior to the hearing, to tribes who have filed a written request for such notice (Government Code §65092).\(^8\)

Under SB 18, local governments must consult with tribes under two circumstances:

- On or after March 1, 2005, local governments must consult with tribes that have requested consultation in accordance with Government Code §65352.3. The purpose of this consultation is to preserve, or mitigate impacts to, cultural places that may be affected by a general plan or specific plan amendment or adoption.

- On or after March 1, 2005, local governments must consult with tribes before designating open space, if the affected land contains a cultural place and if the affected tribe has requested public notice under Government Code §65092. The purpose of this consultation is to protect the identity of the cultural place and to develop treatment with appropriate dignity of the cultural place in any corresponding management plan (Government Code §65562.5).

**Responsibilities of NAHC**

The NAHC is charged with the responsibility to maintain a list of California Native American tribes with whom local governments must consult or provide notices (as required in Government Code §65352.3, §65352, and §65092). The criteria for defining “tribe” for the purpose of inclusion on this list are the responsibility of the NAHC. The list of tribes, for the purposes of notice and consultation, is distinct from the Most Likely Descendent (MLD) list that the NAHC maintains.

Upon request, the NAHC will provide local governments with a written contact list of tribes with traditional lands or cultural places located within a city’s or county’s jurisdiction. These are the tribes that a local government must contact, for purposes of consultation, prior to adoption or amendment of a general plan or specific plan. The NAHC will identify the tribes that must be contacted, based on NAHC’s understanding of where traditional lands are located within the State.

For more information on the NAHC’s roles and responsibilities, contact the NAHC. (See also Part F: Additional Resources)

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\(^7\) Government Code §65352 was amended by SB 18 to include tribes among the entities to whom the proposed action must be referred. The term “substantial amendment” has been in the statute for many years and was not modified by SB 18.

\(^8\) Government Code §65092 was modified by SB 18 to include certain tribes as “persons” that are eligible to request and receive notices of public hearing. “Person” now includes a California Native American tribe that is on the contact list maintained by the NAHC.
Other Elements of SB 18

In addition to the notice and consultation requirements outlined above, SB 18 amended Government Code §65560 to allow the protection of cultural places in the open space element of the general plan. (See Section X.) Open space is land designated in the city or county open space element of the general plan for one or more of a variety of potential purposes, including protection of cultural places.

SB 18 also amended Civil Code §815.3 and adds California Native American tribes to the list of entities that can acquire and hold conservation easements. Tribes on the contact list maintained by the NAHC now have the ability to acquire, on terms mutually satisfactory to the tribe and the landowner, conservation easements for the purpose of protecting their cultural places. (See Section IX.)
Process Overview: General Plan or Specific Plan Adoption or Amendment

As discussed above, SB 18 establishes responsibilities for local government to contact, refer plans to, and consult with tribes. The following table provides an overview of SB 18 requirements related to the adoption or amendment of a general plan or specific plan. All statutory references are to the Government Code (GC).

### Overview of SB 18 Consultation and Notice Requirements

<table>
<thead>
<tr>
<th>Step</th>
<th>OPR Guidelines (GDL) Section and Statutory Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption or amendment of any general plan (GP) or specific plan (SP) is proposed on or after March 1, 2005.</td>
<td>GDL Section IV GC §65352.3(a)(1)</td>
</tr>
<tr>
<td>Local government sends proposal information to NAHC and requests contact information for tribes with traditional lands or places located within the geographical areas affected by the proposed changes.</td>
<td>GDL Section IV GC §65352.3(a)(2)</td>
</tr>
<tr>
<td>NAHC provides tribal contact information.</td>
<td></td>
</tr>
<tr>
<td>OPR recommends that NAHC provide written information as soon as possible but no later than 30 days after receiving a local government’s request</td>
<td></td>
</tr>
<tr>
<td>Local government contacts tribe(s) identified by NAHC and notifies them of the opportunity to consult.</td>
<td>GDL Section IV</td>
</tr>
<tr>
<td>Pursuant to Government Code §65352.3, local government must consult with tribes on the NAHC contact list.</td>
<td></td>
</tr>
<tr>
<td>Tribe(s) responds to a local government notice within 90 days, indicating whether or not they want to consult with the local government.</td>
<td>GDL Section IV GC §65352.3(a)(2)</td>
</tr>
<tr>
<td>Consultation does not begin until/unless a tribe requests it within 90 days of receiving a notice of the opportunity to consult.</td>
<td></td>
</tr>
<tr>
<td>Tribes can agree to a shorter timeframe (less than 90 days) to request consultation.</td>
<td></td>
</tr>
</tbody>
</table>
**Step**

<table>
<thead>
<tr>
<th><strong>OPR Guidelines (GDL) Section and Statutory Reference</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultation begins, if requested by tribe. No statutory limit on the duration of the consultation.</td>
</tr>
<tr>
<td>GDL Section IV</td>
</tr>
<tr>
<td>Consultation may continue through planning commission or board of supervisors/city council deliberation on plan proposal.</td>
</tr>
</tbody>
</table>

Local government continues normal processing of GP/SP adoption or amendment.
(CEQA review, preparation of staff reports, consultation, etc., may be ongoing.)

At least 45 days before local government adopts or substantially amends GP/SP, local government refers proposed action to agencies, including tribe(s).
Referral required regardless of whether or not there has been prior consultation.
This does not initiate a new consultation process.
This opens 45 day comment period before approval by board of supervisors/city council.
Referral required on or after March 1, 2005.

At least 10 days before public hearing, local government provides notice of hearing to tribes and any other persons who have requested such notice.

Public hearing of board of supervisors/city council to take final action on the GP/SP.

**Note:** The Permit Streamlining Act (PSA) (GC §65920 et seq.) establishes time limits for public agencies to take action on privately initiated development projects. Some general plan amendments may involve a private applicant for a development project. The PSA does not apply to a project that requires approval by a legislative act, such as a general plan amendment or rezone, even if there is a quasi-judicial approval involved (such as a use permit or subdivision map). Therefore, time limits for project approval under the PSA should not interfere with a local government’s process for consultation.
Part B
When and How to Consult with California Native American Tribes

Sections IV and V of the 2005 Supplement provide step-by-step guidance to local government agencies on how and when to consult with tribes, including when to provide certain types of notices during the planning process. It is very important to review the information in Part C (Pre-Consultation) before undertaking consultation on a general plan or specific plan proposal.

IV. Consultation: General Plan and Specific Plan Adoption or Amendment

Each time a local government considers a proposal to adopt or amend the general plan or specific plan, they are required to contact the appropriate tribes identified by the NAHC. If requested by tribes, local governments must consult for the purpose of preserving or mitigating impacts to cultural places. The following section provides basic guidance to local governments on the notification and consultation requirements in Government Code §65352.3.

What Triggers Consultation?

Government Code §65352.3 requires local governments to consult with tribes prior to the adoption or amendment of a general plan or specific plan proposed on or after March 1, 2005.

Local governments should consider the following when determining whether a general plan or specific plan adoption or amendment is subject to notice and consultation requirements:

- In the case of an applicant-initiated plan proposal, if the local government accepts a complete application (as defined in Government Code §65943) on or after March 1, 2005, the proposal is subject to Government Code §65352.3.
- In the case of a general plan or specific plan amendment initiated by the local government, any proposal introduced for study in a public forum on or after March 1, 2005 is subject to Government Code §65352.3. A legislative body must take certain actions to initiate, or propose, a general plan or general plan amendment. These actions must be taken in a duly noticed public meeting, and may include, but are not limited to, any of the following: appropriation of funds, adoption of a work program, engaging the services of a consultant, or directing the planning staff to begin research on the activity.

Under Government Code §65352.3, only if a tribe is identified by the NAHC, and that tribe requests consultation after being contacted by a local government, must a local government consult with the tribe on the plan proposal.

Local governments are encouraged to consult with tribes as early as possible and may, if appropriate, begin consultation even before a formal proposal is submitted by an applicant or initiated by the local government.
Identifying Tribes through the NAHC

Once a local government or private applicant initiates a proposal to adopt or amend a general plan or specific plan, the local government must send a written request to the NAHC asking for a list of tribes with whom to consult. OPR recommends that the written request be sent to the NAHC as soon as possible. Local governments should consider the following points when submitting a request to the NAHC:

All written requests should be sent to the NAHC via certified mail or by fax.

Requests to the NAHC should include the specific location of the area that is subject to the proposed action, preferably with a map clearly showing the area of land involved.

Requests should clearly state that the local government is seeking information about tribes that are on the “SB 18 Consultation List.”

Contact information for the NAHC:
Native American Heritage Commission
915 Capitol Mall, Room 364
Sacramento, CA 95814
Phone: 916-653-4082
Fax: 916-657-5390
http://www.nahc.ca.gov

A sample form for submitting a request to the NAHC is provided in Exhibit A. The tribal consultation list request form is also available on the NAHC website.

The NAHC will provide local governments with a written contact list of tribes with traditional lands or cultural places located within the local government’s jurisdiction. For each listed tribe, the NAHC will provide the tribal representative’s name, name of tribe, address, and phone number (if available, fax and email address). Although there is no statutory deadline for NAHC to respond to the local government, OPR recommends that the NAHC provide written contact information as soon as possible but no later than 30 days after receiving a written request from the local government.

Contacting Tribes Pursuant to Government Code §65352.3

Once a tribal contact list is received from the NAHC, local governments must contact the appropriate tribe(s) and invite them to participate in consultation. OPR suggests that local governments contact tribes as soon as possible upon receiving the tribal contact list. While the statute does not specify by what means tribe(s) should be contacted, OPR suggests that local governments send a written notice by certified mail with return receipt requested. Sending a written notice does not preclude a local government from also contacting the tribe by telephone, FAX, or e-mail.

Notices should be concise, clear, and informative so that tribes understand what they are receiving. Try to avoid using a standard public notice format to invite a tribe to consult, as most public notices do not contain sufficient information about the proposed action to enable a tribe to
respond. Keep in mind that the purpose of this notice is to invite a tribe to request consultation. Notices sent from a local government to a tribe, inquiring whether consultation is desired, should contain the following information:

- A clear statement of purpose, inviting the tribe to consult and declaring the importance of the tribe’s participation in the local planning process.
- A description of the proposed general plan or specific plan being considered, the reason for the proposal, and the specific geographic area(s) that will be affected by the proposal. Relevant technical documents should be provided with a concise explanation that clearly describes the proposed general plan or specific plan amendment and its potential impacts on cultural resources, if known.
- Maps that clearly detail the geographic areas described in the explanation. Maps should be in a reasonable scale with sufficient references for easy identification of the affected areas.
- The deadline (date) by which the tribe must request a consultation with the local government. By law, tribes have 90 days from the date of receipt of the notice to request consultation (Government Code §65352.3(a)(2)).
- Contact information for representatives of the local government to whom the tribe should respond.
- Contact information for the project proponent/applicant and landowner(s), if applicable.
- Technical reports, including summaries of cultural resource reports and archaeological reports applicable to that tribe’s cultural place(s), if available.
- Information on proposed grading or other ground-disturbing activities, if applicable. (This may be included in the project description.)

Subject to confidentiality procedures, both parties should maintain clear records of communications, including letters, telephone calls, and faxes. Both parties may send notices by certified mail and keep logs of telephone calls and faxes. Any returned or unanswered correspondence should be retained in order to verify efforts to communicate. Documentation of notification and consultation requests should be included in the local government’s public record.

In addition to the above recommendations, local governments may, in cooperation with tribes, develop notification procedures as a part of consultation protocols established in cooperation with a tribal government. Local governments should be aware that some tribes already have consultation protocols. In addition, local governments may adopt policies regarding consultation with a tribal government. (See Section VI.)

**After Notification is Sent to the Tribe**

Once local governments have sent notification, tribes are responsible for requesting consultation. Pursuant to Government Code §65352.3(a)(2), each tribe has 90 days from the date on which they receive notification to respond and request consultation. Some key points to consider include:
The time period for consultation (undefined) is independent of the time period for tribes to request consultation (90 days).

Local governments should be aware that tribes may require the entire 90-day period allowed by law to respond to a consultation request. Tribal governing bodies may need to meet to take a formal position on consultation.

Local governments and tribal governments may consider addressing the method and timing of a tribe’s response to a consultation request in a jointly-developed consultation protocol. (See Section VI.)

At their discretion, tribes can agree to a shorter timeframe (less than 90 days) to respond and request consultation.

After the information about a proposed plan or plan amendment is received by the tribe, local governments should cooperate to provide any additional pertinent information about the proposed plan or plan amendment that the tribe may request. Local governments may consider extending the 90 day timeframe for the tribe to review the new information and respond accordingly.

If the tribe does not respond within 90 days or declines consultation, consultation is not required under Government Code §65352.3.

Conducting Consultation on General Plan or Specific Plan Adoption or Amendment

Once a tribe requests consultation, consultation for the purpose of preserving or mitigating impacts to cultural places should begin within a reasonable time. Consultation should focus on how the proposed general plan or specific plan amendment or adoption might impact cultural places located on land affected by the plan proposal. The objectives of consultation, according to the legislative intent of SB 18, include:

- Recognizing that cultural places are essential elements in tribal culture, traditions, heritages and identities.
- Establishing meaningful dialogue between local and tribal governments in order to identify cultural places and consider cultural places in local land use planning.
- Avoiding potential conflicts over the preservation of Native American cultural places by ensuring local and tribal governments have information available early in the land use planning process.
- Encouraging the preservation and protection of Native American cultural places in the land use process by placing them in open space.
- Developing proper treatment and management plans in order to preserve cultural places.
- Enabling tribes to manage and act as caretakers of their cultural places.

Consultation is a process in which both the tribe and local government invest time and effort into seeking a mutually agreeable resolution for the purpose of preserving or mitigating impacts to a cultural place, where feasible. Government Code §65352.4 provides a definition of consultation for use by local governments and tribes:
Consultation means the meaningful and timely process of seeking, discussing, and considering carefully the views of others, in a manner that is cognizant of all parties’ cultural values and, where feasible, seeking agreement. Consultation between government agencies and Native American tribes shall be conducted in a way that is mutually respectful of each party’s sovereignty. Consultation shall also recognize the tribes’ potential needs for confidentiality with respect to places that have traditional tribal cultural significance.

Effective consultation is an ongoing process, not a single event. The process should focus on identifying issues of concern to tribes pertinent to the cultural place(s) at issue – including cultural values, religious beliefs, traditional practices, and laws protecting California Native American cultural sites – and on defining the full range of acceptable ways in which a local government can accommodate tribal concerns.

Items to Consider When Conducting Consultation

The following list identifies recommendations for how local governments and tribes may approach consultation on general plan and specific plan proposals.

As defined in Government Code §65352.4, consultation is to be conducted between two parties: the local government and the tribe. Both parties to the consultation are required to carefully consider the views of the other.

Consultation does not necessarily predetermine the outcome of the plan or amendment. In some instances, local governments may be unable to reach agreement due to other state laws or competing public policy objectives.

Local governments must consult with each tribe who is identified by the NAHC and requests consultation. The NAHC will identify whether there are, in fact, any tribes with whom the local government must consult. One or more tribes may have traditional cultural ties to land within the local government’s jurisdiction and have an interest in preserving cultural places on those lands. Therefore, local governments may have to consult with more than one tribe on any particular plan proposal.

OPR recommends that local governments consult with tribes one at a time (individually). If multiple tribes are involved and willing to jointly consult, local governments may consult with more than one tribe at a time.

When a local government first contacts a tribe, its initial inquiry should be made to the tribal representative identified by the NAHC. OPR recommends that a local government department head or other official of similar or higher rank make the initial contact.

Government leaders of the two consulting parties may consider delegating consultation responsibilities (such as attending meetings, sharing information, and negotiating the needs and concerns of both parties) to staff. Designated representatives should maintain direct relationships with and have ready access to their respective government leaders. These individuals may, but are not required to, be identified in a jointly-developed consultation protocol. (See Section VI.) In addition, the services of other professionals (attorneys,
contractors, or consultants) may be utilized to develop legal, factual, or technical information necessary to facilitate consultation.

Simply notifying a tribe of a plan proposal is not the same as consultation.⁹

Local governments should be aware of the potential for vast differences in tribal governments’ level of staffing and other resources necessary to participate in the manner required by Government Code §65352.3 and §65352.4. Some may be able to respond more promptly and efficiently than others. Local governments should keep this in mind if and when developing a consultation protocol with a tribe. (See Section VI.)

As a part of consultation, local governments may conduct record searches through the NAHC and California Historic Resources Information System (CHRIS) to determine if any cultural places are located within the area(s) affected by the proposed action. Local governments should be aware, however, that records maintained by the NAHC and CHRIS are not exhaustive, and a negative response to these searches does not preclude the existence of a cultural place. A tribe may be the only source of information regarding the existence of a cultural place.

Local governments should be aware that the confidentiality of cultural places is critical to tribal culture and that many tribes may seek confidentiality assurances prior to divulging information about those sites. (See Section VIII.)

Tribal consultation should be done face-to-face. If acceptable to both parties, local and tribal governments may wish to define circumstances under which parts of the consultation process can be carried out via conference calls, e-mails, or letters. (See Section VIII.)

Tribal consultations should be conducted in a setting that promotes confidential treatment of any sensitive information that is shared about cultural places. Consultation should not take place in public meetings or public hearings.

The time and location of consultation meetings should be flexible to accommodate the needs of both the local government and tribe. Local governments should recognize that travel required for in-person consultation may be time-consuming, due to the rural location of a tribe. Local governments should also take into account time zone changes when setting meeting times. Local governments should offer a meeting location at the city hall, county administrative building, or other appropriate location. Local governments should also be open to a tribe’s invitation to meet at tribal facilities.

The local government and tribe can agree to mutually invite private landowners to participate in consultation, if both parties feel that landowner involvement would be appropriate.

Local governments are encouraged to establish a collaborative relationship with tribes as early as possible, prior to the need to consult on a particular general plan or specific plan

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⁹ In Pueblo of Sandia v. United States, 50 F.3d 856 (10th Cir. 1995), the court held that the U.S. Forest Service had not fulfilled its consultation responsibilities under the National Historic Preservation Act by merely sending letters to request information from tribes. The court ruling held that written correspondence requesting consultation with a tribe was not sufficient for the purpose of conducting consultation as required by law, and that telephone calls or more direct forms of contact may be required.
amendment or adoption. Local governments may consider conducting pre-consultation meetings and developing consultation protocols in cooperation with tribes. *(See Section VI.)*

Both parties should attempt to document the progress of consultation, including letters, telephone calls, and direct meetings, without disclosing sensitive information about a cultural place. Local governments may also want to document how the local government representative(s) fulfilled their obligations under Government Code §65352.3 and §65352.4.

**When is Consultation Over?**

Alan Downer, of the Advisory Council on Historic Preservation, described consultation as “conferring between two or more parties to identify issues and make a good faith attempt to find a mutually acceptable resolution of any differences identified.”*10* Differences of opinion and of priorities will arise in consultation between local and tribal governments. Whenever feasible, both local and tribal governments should strive to find mutually acceptable resolutions to differences identified through consultation.

When engaging in consultation, local government and tribal representatives should consider leaving the process open-ended to allow every opportunity for mutual agreement to be reached. Some consultations may involve highly sensitive and complex issues that cannot be resolved in just one discussion. Consultation may require a series of meetings before a mutually acceptable agreement may be achieved. Consultation must be concluded prior to the formal adoption or amendment of a general plan or specific plan.

Consultation, pursuant to Government Code §65352.3 and §65352.4, should be considered concluded at the point in which:

- the parties to the consultation come to a mutual agreement concerning the appropriate measures for preservation or mitigation; or
- either the local government or tribe, acting in good faith and after reasonable effort, concludes that mutual agreement cannot be reached concerning appropriate measures of preservation or mitigation.

**V. Consultation: Cultural Places Located in Open Space**

On and after March 1, 2005, if land designated, or proposed to be designated as open space contains a cultural place, and if an affected tribe has requested notice of public hearing under Government Code §65092, then local governments must consult with the tribe. The purpose of this consultation is to determine the level of confidentiality required to protect the specific identity, location, or use of the cultural place, and to develop treatment with appropriate dignity of the cultural place in any corresponding management plan (Government Code §65562.5). This consultation provision does not apply to lands that were designated as open space before March 1, 2005.

What Triggers Consultation?

Government Code §65562.5 applies to land that is designated, or proposed to be designated, as open space, on or after March 1, 2005. Local governments must consider several criteria when determining whether consultation is required, prior to designating open space on or after March 1, 2005.

Local governments must first learn whether the land designated, or proposed to be designated, as open space contains a cultural place. The following are methods by which local governments may be informed if a cultural place is located on designated or proposed open space:

- Conduct a record search through the NAHC to learn whether any listed cultural places are located on land proposed to be designated as open space. The local government should provide maps of lands proposed as open space to the NAHC with a request to identify whether there are any cultural places on the property. Because the NAHC’s sacred lands file is confidential, the commission will only divulge the presence or absence of a listed site and will direct the local government to the appropriate tribe(s) for more information.
- Conduct a record search through CHRIS to learn whether any listed cultural places are located on land proposed to be designated as open space. Local governments should enter into agreements with CHRIS information centers to establish procedures and protocols for requesting searches of historical resource records.
- Request that tribes identify the existence of any cultural places on the proposed open space land. Local governments should send a written request to the NAHC asking for a written list of tribes that have traditional cultural ties to the proposed open space. The NAHC will provide tribal contact information. Local governments should contact each tribe on the list provided by the NAHC to learn whether any cultural places are located on the land proposed as open space. Local government should provide the tribe with a sufficiently detailed map of the open space together with a concise notice as to why the tribe is being contacted. (Note: This contact is strictly for the purpose of identifying whether a cultural place is or may be located on the proposed open space land. It does not start consultation with a tribe.)

Local governments should be aware that records maintained by the NAHC and CHRIS are not exhaustive, and a negative response to searches does not preclude the existence of a cultural place. In most instances, and especially because of associated confidentiality issues, it is likely that tribes will be the only source of information regarding certain cultural places.

After a local government learns that a cultural place is or may be located on land designated or proposed to be designated as open space, the local government must notify the appropriate tribes of the opportunity to participate in consultation. The appropriate tribes are those which have: (1) been identified by the NAHC, and (2) requested notice of public hearing from the local government pursuant to Government Code §65092.
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Conducting Consultation Regarding Open Space

The purpose of this consultation is to determine the level of confidentiality required to protect the specific identity, location, character, or use of the cultural place and to develop treatment with appropriate dignity of the cultural place in any corresponding open space management plan. The reference to “any corresponding management plan” is not meant to imply that there is such a plan or that the local government must develop such a management plan. This language is intended to encourage consideration of management policies and practices which may be discussed between the local government and tribe and incorporated into a new or existing management plan for the cultural place.

The following are examples of appropriate items to consider and discuss during consultation:

- Encourage tribal involvement in the treatment and management of the cultural place though contracting, monitoring, co-management, and other forms of joint local-tribal participation.
- Tribes may only wish to disclose a sufficient amount of information to protect the site and to allow for the proper treatment and management of the cultural place. (See Section VIII.)
- Tribes may wish to have access to cultural places located on open space for gathering, performing ceremonies and/or helping maintain the site.
- Tribes may want to recommend management practices that avoid disturbing or impacting the cultural place.
- Tribes may wish to discourage certain land uses (e.g. recreation) within the open space that could adversely impact the cultural place. Local governments may be asked to consider appropriate land uses in the open space designation that would avoid direct impacts to the cultural place.

The designation of open space, as provided in Government Code §65562.5, may but does not always, involve amending the general plan. In some jurisdictions, designation of open space may occur through rezoning of land from one zone designation to an open space zone designation, without the need for a general plan amendment. However, for proposals to designate open space that require a general plan or specific amendment, the local government should consider the above recommendations as well as the recommendations outlined in Section IV of these guidelines.

When is Consultation Over?

Please refer to Section IV for additional information regarding the meaning of consultation.
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Part C
Pre-Consultation

Section VI provides advice to local governments that is intended to help them more effectively engage in consultation with tribes. This part of the 2005 Supplement provides information that may help local governments establish working relationships with tribes prior to entering into the required consultation pursuant to Government Code §65352.3 and §65562.5.

VI. Preparing for Consultation

As discussed above, Government Code §65352.3 requires consultation during the process of amending or adopting general plans or specific plans. In addition, Government Code §65562.5 requires consultation to determine the proper level of confidentiality to protect and treat a cultural place with appropriate dignity, where such places are located on lands to be designated as open space. Before engaging in consultation in either of these cases, local governments may want to consider developing relationships with tribes that have traditional lands within their jurisdiction. Although not required by law, these pre-consultation efforts may develop a foundation for a mutually respectful and cooperative relationship that helps to ensure more smooth and effective communication in future consultations.

Local governments may wish to consider the following when undertaking pre-consultation meetings:

- Contact the NAHC to obtain a list of all appropriate tribes with whom to pre-consult. Because this list may be revised over time by the NAHC, local governments should periodically request updated contact lists.
- Contact the NAHC and CHRIS to learn if any historical or cultural places are located within the city’s or county’s jurisdiction. (Note that the NAHC and CHRIS have different procedures for searching information about cultural sites. See Part F for more information about each organization and how to contact them. As previously noted, NAHC and CHRIS records pertaining to cultural places are not exhaustive, and a negative response to these searches does not preclude the existence of a cultural place.)
- Invite each tribal government’s leaders to meet with local government leaders for the purpose of establishing working relationships and exchanging information about respective governmental structures, practices, and processes. Pre-consultation meetings may include discussion about community goals, planning priorities, and how cultural places play a role in the tribal culture.
- Hold informational workshops or meetings with the tribe(s) to discuss the general plan process, the existing general plan, and any contemplated amendments. Local governments should not expect or ask a tribe to share confidential information in a meeting with other tribes or the general public.
- Ask tribes whether they have existing consultation protocols.
Develop a consultation protocol that addresses how a cooperative relationship can be maintained and how future consultations should be conducted. Some tribes may already have established protocols through working with other agencies, such as state and federal entities, that can be used as models.

If a tribe and local government decide to develop a consultation protocol, both parties should suggest topics that they believe will facilitate consultation. The following are examples of items that may be appropriate to discuss and include in a jointly-developed consultation protocol:

- Representative(s) from each consulting party who will be designated to participate in consultations and manage the information resulting from the consultations.
- Key points in the consultation process when elected government leaders may need to be directly involved in consultation.
- Method(s) of contact preferred by the tribal government and additional tribal representatives that the local government should contact regarding a proposed action.
- Procedures for giving and receiving notice, including method and timing.
- Preferred method(s) of consultation. While in-person consultation is recommended, it may be acceptable to both parties that certain aspects of consultation occur through conference calls, e-mails, or letters.
- Preferred locations of consultation meetings.
- The tribe’s willingness to participate in joint consultation, should a specific site be of interest to more than one tribe.
- Procedures to allow tribal access to the local government’s consultation records.
- Procedures for maintaining accurate, up-to-date contact information.

Over time, the initial approach to consultation may need to be updated. Both parties should be open to identifying and agreeing on changes to their consultation protocol.
Part D
Preservation, Mitigation, Confidentiality, and Landowner Participation

Sections VII through IX provide advice to local governments for considering issues such as appropriate means to preserve, or mitigate impacts to, cultural places; methods to protect the confidentiality of cultural places; and ways to encourage the participation of landowners in voluntary preservation efforts.

VII. Preservation of, or Mitigation of Impacts to, Cultural Places

Government Code §65352.3 requires local governments to conduct consultations with tribes (when requested) for the purpose of “preserving or mitigating impacts” to California Native American cultural places. In the course of adopting or amending a general plan or specific plan, local governments may be informed of the existence of a cultural place within the affected area. Should a tribe request consultation to discuss any impacts to the cultural place, local governments should consider a variety of factors when participating in the consultations, including: the history and importance of the cultural place, the adverse impact the local government action may have on the cultural place, options for preserving the cultural place, and options for mitigating impacts of the proposal to the cultural place.

When participating in consultations, it is important that local governments consider that, because of philosophical differences, mitigation will not always be viewed as an appropriate option to protect cultural, and often irreplaceable, places. Many tribes may determine that impacts to a cultural place cannot be mitigated; that the only appropriate treatment may be to preserve the cultural place without impact to its physical or spiritual integrity. Of course, this is not to say that tribes will not engage in discussions regarding mitigation of impacts to their cultural places, but local governments should consider the vastly different perspectives that tribes may have. What a local government may consider to be acceptable treatment under current environmental, land use, and cultural resource protection laws, may not be considered by a tribe to be acceptable treatment for a sacred or religious place.

The following is a discussion of preservation and mitigation, as mentioned in Government Code §65352.3. Local governments should check with their legal counsels to identify any other legal obligations to preserve or mitigate impacts to Native American cultural resources.

What are Preservation and Mitigation?

Preservation is the conscious act of avoiding or protecting a cultural place from adverse impacts including loss or harm. Mitigation, on the other hand, is the act of moderating the adverse impacts that general plan or specific plan adoption or amendment may have on a cultural place.
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While local governments should strive to help preserve the integrity of, access to, and use of cultural places\(^{11}\), mitigation may often be achieved through a broad range of measures:

- Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
- Rectifying the impact by repairing, rehabilitating, or restoring the impacted cultural place.
- Reducing or eliminating the impact over time through monitoring and management of the cultural place.

Other methods of mitigation may include:

- Designation of open space land in accordance with Government Code §65560(b).
- Enhancement of habitat or open space properties for protection of cultural place.
- Development of an alternate site suitable for tribal purposes and acceptable to the tribe.
- Other alternative means of preserving California Native American cultural features, where feasible.

It is important that local governments consider that mitigation measures may largely differ depending on customs of a particular tribe, the characteristics and uses of a site or object, the cultural place’s location, and the importance of the site to the tribe’s cultural heritage. Where a cultural place is affected by a proposed general or specific plan adoption or amendment, consultations with tribes should focus on preserving, or mitigating the impacts to, that specific cultural place.

**Seeking Agreement Where Feasible**

Although Government Code §65352.3(a) requires consultation for the purpose of preserving or mitigating against the adverse impacts that a general plan or specific plan adoption or amendment may have on a cultural place, there is no requirement to preserve a cultural place or adopt mitigation measures, if agreement cannot be reached. Under the definition of “consultation” within Government Code §65352.4, local governments and tribes are required to carefully consider each other’s views and are required to seek an agreement, “where feasible.” For the purposes of Government Code §65352.4, agreements should be considered “feasible” when capable of being accomplished in a successful manner within a reasonable time taking into account economic, environmental, social and technological factors.\(^{12}\) If, after conducting consultations in good faith and within the spirit of the definition, the tribe or local government cannot reach agreement on preservation or mitigation of any impact to a California Native American cultural place, neither party is required to take any action under Government Code §65352.3(a).

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\(^{11}\) Cultural Places referring to places, features, and objects under Government Code §65352.3(a) and described in Government Code §§5097.9 and 5097.995.

\(^{12}\) See State of California General Plan Guidelines, Governor’s Office of Planning & Research, Glossary, page 261.
Monitoring and Management
During consultations, local governments should consider the involvement of tribes in the ongoing treatment and management of cultural places, objects, or cultural features through a specific monitoring program, co-management, or other forms of participation.

Where a cemetery, burial ground, or village site may be present, the planning of treatment and management activities should address the possibility that California Native American human remains may be involved when protecting cultural features. Local governments should consider working with tribes to develop an appropriate plan for the identification and treatment of such discoveries in accordance with Public Resources Code §5097.98.

Private Landowner Involvement
During consideration of a proposed general plan adoption or amendment, a local government may discover or be informed of a cultural place that exists on privately owned land within an affected area. In such an instance, local governments should first contact the appropriate tribe or tribes to offer consultations and determine an acceptable level of landowner involvement. Local governments should be aware that there may be some occasions where a tribe may prefer to maintain strict confidentiality without the inclusion of a private, third party landowner.

If a tribe is interested in involving the landowner in preservation or mitigation activities, the local government should consider facilitating such involvement. It is important that local governments and tribes understand that there is no statutory requirement to include private landowners under the government-to-government consultations requirements of Government Code §65352.3(a). However, because landowner participation is encouraged, local governments may consider suggesting the following methods to facilitate landowner involvement:

Suggesting that the tribe contact the private landowner directly to facilitate discussions between the tribe and landowner.

Offering to contact the private landowner directly on behalf of the tribe.

Suggesting that the private landowner be included as a party to the consultations.

VIII. Confidentiality of Information
Protecting the confidentiality of California Native American prehistoric, archaeological, cultural, spiritual, and ceremonial places is one of the most important objectives of SB 18. This is clearly evidenced by SB 18’s legislative intent as well as its statutory additions and amendments which address the issue of confidentiality and requires “each city and county to protect the confidentiality of information concerning” cultural places.13 By maintaining the confidentiality of a cultural place, including its location, traditional uses, and characteristics, local governments can help assure tribes of continued access and use of these cultural places, in addition to aiding in the preservation of a cultural place’s integrity. However, local governments should take into consideration other state and federal laws which may impose conflicting public policy priorities or requirements.

13 See SB 18 §1(b)(3), (Burton, Ch. 905, Stat. 2004); Govt. Code §§ 65040.2(g)(3), 65352.3, 65352.4, and 65562.5.
Public Disclosure Laws

The California Public Records Act (Government Code §6250 et. seq.) and California’s open meeting laws applying to local governments (The Brown Act, Government Code §54950 et. seq.) both have implications with regard to maintaining confidentiality of California Native American cultural place information. Local governments are encouraged to carefully consider these laws in greater detail, and adopt or incorporate these recommendations into their own confidentiality procedures in order to avoid the unintended disclosure of confidential cultural place information.

The California Public Records Act (CPRA)

Subject to specified exemptions, the CPRA provides that all written records maintained by local or state government are public documents and are to be made available to the public, upon request. Written records include all forms of recorded information (including electronic) that currently exist or that may exist in the future. The CPRA requires government agencies to make records promptly available to any citizen who asks, unless an exemption applies.

While the CPRA does exempt certain types of information from public disclosure, the law is presently unclear as to whether a public agency would be required to disclose records (written and in a local government’s possession) pertaining to cultural places under a CPRA request. However, federal and state laws do impose significant restrictions on the maintenance, use, and disclosure of records and information pertaining to tribal cultural places. Mindful of these restrictions, and the state’s guarantee that access to information concerning the conduct of the people's business is a fundamental right of every person in California, and that any exceptions to disclosure are narrowly construed,14 public records concerning the nature and specific location of a tribal cultural place should be disclosed by a local agency in response to a request under Government Code §6250 unless the local agency makes a written determination that:

1. disclosure of the information would create an unreasonable risk of harm, theft, or destruction of the resource or object, including individual organic or inorganic specimens; or
2. disclosure is inconsistent with other applicable laws protecting the resource or object; or
3. in accordance with Government Code §6255 on the facts of a particular case the public interest served by not making the record public clearly outweighs the public interest served by disclosure of the record.

The Brown Act

The Brown Act governs the legislative bodies of all local agencies within California. It requires that meetings held by these bodies be “open and public.” Under this Act, no local legislative body may take an action in secret, nor will the body’s action be upheld if it is in violation of California’s open meeting laws. The Brown Act defines a “meeting” as a gathering of a majority of the members of a applicable body to hear, discuss, or deliberate on matters within the agency’s or board’s jurisdiction.

14 See California Constitution, Article I, Section 3, Subdivision (b)(2); and County of Los Angeles v. Superior Court (Axelrad), 82 Cal.App.4th 819 (2000).
While the Brown Act does contain some exceptions for “closed meetings,” none of these exceptions would allow the quorum of a local legislative body to participate in tribal consultations within a closed meeting. Should a local legislative body participate in confidential tribal consultations, it is important that they do so as an advisory committee with less than a quorum, so as to not invoke the Brown Act’s requirements of public participation (see Government Code §54952(b)). Otherwise, the Brown Act will require that the consultations be held in public, thereby defeating the purpose of confidentiality, or, alternatively, any decisions made by the quorum of the body within a closed meeting would be rendered invalid.

In order to efficiently conduct tribal consultation meetings, in addition to maintaining confidentiality at all times, local governments are encouraged to develop procedures in advance that would designate a committee or agency in charge. In doing so, local governments should consider the problems associated with elected official participation within tribal consultations, and should tailor their procedures accordingly.

**Public Hearings**

General plan amendments, specific plan amendments, and the adoption of a general or specific plan each require both a planning commission and a city council or board of supervisors to conduct public hearings. The decision to approve or deny these proposals must be based in reason and upon evidence in the record of the public hearing. When addressing an adoption or amendment involving a cultural place, elected officials will need to be apprised of the cultural site implications in order to make informed decision. However, to maintain the confidentiality of this cultural place information, local governments and tribes, during consultations, should agree on what non-specific information may be disclosed during the course of a public hearing. Additionally, local governments should avoid including any specific cultural place information within CEQA documents (such as Environmental Impact Reports, Negative Declaration, and Mitigated Negative Declarations) or staff reports which are required to be available at a public hearing.

**Additional Confidentiality Procedures**

Additionally, local governments should consider the following items when considering steps to be taken in order to maintain confidentiality:

- Local governments should develop “in-house” confidentiality procedures.
- Procedures should be established to allow for tribes to share information with local government officials in a confidential setting.
- Only those tribal designees, planning officials, qualified professional archaeologists, and landowners involved in the particular planning activity should obtain information about a specific site.
- Participating landowners should be asked to sign a non-disclosure agreement with the appropriate tribe prior to gaining access to any specific site information.
- Local governments should not include detailed (confidential) information about cultural places in any of its public documents.
Possible procedures to require local government to notify participating tribes and landowners whenever records containing specific site information have been requested for public disclosure.

Local governments should also keep in mind that the terms for confidentiality may differ depending upon the nature of the site, the tribe, the local government, the landowner, or who proposes to protect the site. Local governments should collaborate with tribes to develop informational materials to educate landowners regarding the cultural sensitivity of divulging site information, explaining the tribe’s interest in maintaining the confidentiality and preservation of a site. Landowners should be informed of criminal penalties within the law for the unlawful and intentional destruction, degradation or removal of California Native American cultural or spiritual places located on public or private lands (Public Resources Code §5097.995).

Confidentiality Procedures for Private Landowner Involvement

In order to successfully preserve or mitigate impacts to a California Native American cultural place, local governments and tribes may find it necessary or advantageous to involve private landowners early in the consultation process. Often, landowners may not be aware that a cultural place exists on their property, or alternatively, may not realize that the site has become subject to a general plan adoption or amendment. Due to the confidential nature of certain information involved, local governments should consider working with tribes to adopt procedures that would balance the value of landowner involvement with the need for cultural place confidentiality.

Local governments and California Native American tribes may wish to consider the following procedures that would inform and potentially involve landowners in the consultation process, without compromising the confidentiality of a cultural place:

Local governments, at the request of a tribe, may consider contacting a landowner directly and, without disclosing the exact location or characteristics of the site, inform the landowner of the existence of a culturally significant place on their property. A local government may consider inquiring as to whether the landowner would be willing to further discuss the matter directly with the appropriate tribal representative under a non-disclosure agreement.

Local governments may consider giving the landowner’s contact information to a tribe so that the tribe may contact the landowner directly. Discussion about conservation easements is an example of a case in which a tribe and landowner may wish to meet without the direct participation of the local government.

Local governments may also consider informing a landowner of the ability of landowners to access CHRIS for cultural resource information specific to their land. Local governments should keep in mind that the CHRIS system does not contain a catalog of every cultural place within California.

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15 Due to a drafting error, SB 18 contains multiple references to Public Resources Code (PRC) §5097.995 which is no longer in existence. In 2004, PRC §5097.995 was amended and renumbered to PRC §5097.993 by Senate Bill 1264 (Chapter 286). Local governments should refer to PRC §5097.993 when looking for PRC §5097.995.
IX. Procedures to Facilitate Voluntary Landowner Protection Efforts

In addition to their own consultation with tribes, local governments may help facilitate landowner participation in preserving and protecting cultural places. While each city and county should develop its own policies on landowner participation, general strategies for encouraging landowner awareness of and participation in cultural place protection may include:

- Collaborating with local tribes to offer cultural awareness and other educational events for landowners.
- Encouraging landowner participation in discussions about appropriate preservation and mitigation measures.
- Promoting the use of conservation easements and other private conservation efforts.

It should be noted that SB 18 does not require landowners to dedicate or sell conservation easements for the purpose of cultural place preservation. Neither are local governments required to play a direct role in any private conservation activity. Government Code §65040.2(g), however, does require OPR to recommend procedures to facilitate voluntary landowner participation in the preservation and protection of cultural places.

Landowner Education and Participation

Public workshops, seminars, and other educational sessions may provide forums for tribal representatives to share tribal and cultural information and discuss general protection concerns with landowners. These sessions may build cultural awareness, develop landowner understanding of the importance of cultural places, and also encourage further dialogue between tribes and landowners. These sessions should generally inform landowners of the importance of cultural places and should not compromise the confidentiality of a specific cultural place.

Local governments may also encourage landowner participation in discussions about preserving or mitigating impacts to a cultural place located on a landowner’s private property. (See Section VII and Section VIII for further information.)

Private Conservation Efforts

Although local governments are not required to play a direct role in any private conservation activity, they can promote the use of conservation easements and other conservation programs to protect cultural places. Local governments may consider adoption of a policy to encourage voluntary landowner participation in protection programs. Local governments may also develop and distribute informational materials about potential incentives for private conservation efforts, such as Mills Act tax credits or the tax benefits of donating or selling conservation easements.

A conservation easement is a voluntary agreement between a landowner and an authorized party (including a tribe pursuant to Civil Code 815.3(c)) that allows the easement holder to limit the type or amount of development on the property while the landowner retains title to the land. The landowner is compensated for voluntarily giving up some development opportunities. The easement is binding upon successive owners of the land. It is common for a conservation
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easement to be recorded against the property as a way to inform future purchasers of the existence of an easement. Granting of a conservation easement may qualify as a charitable contribution for tax purposes.

Should a landowner choose to sell a conservation easement, the landowner should first consult with all tribes affiliated with the land on which the easement is proposed. It is also recommended that tribes hold conservation easements only within their areas of cultural affiliation.

As an alternative to conservation easements, local governments may also promote private preservation of cultural places through the use of Memoranda of Understanding (MOU). As a direct agreement between a landowner and tribe, a MOU allows a tribe and landowner to agree on appropriate treatment of cultural places located on the landowner’s private property and may give certain privileges to tribes, such as access to perform ceremonial rituals. MOUs may also be used to facilitate co-management by tribes, landowners, and conservation organizations. For example, if a conservation easement established for wildlife protection also contains a cultural place, the landowner, conservation entity, and tribe could agree on co-management (in the MOU) that protects both the habitat and cultural place.
Part E
Open Space

Section X provides information for incorporating the protection of cultural places into the open space element of the general plan.

X. Open Space for the Protection of Cultural Places

SB 18 amended Government Code §66560 to include open space for the protection of cultural places as an allowable purpose of the open space element. Local governments may, but are not required to, consider adopting open space policies regarding the protection of cultural places. Local governments may wish to consider the following when and if they develop such policies:

- Limiting the types of land uses allowed in an open space designation in order to protect the cultural place from potentially harmful uses.
- Facilitating access to tribes for maintenance and traditional use of cultural places.
- Protecting the confidentiality of cultural places by not disclosing specific information about their identity, location, character, or use.
- Giving developers incentives to protect cultural places through voluntary measures.
- Incorporating goals for protection of cultural places in open space that is also part of a regional habitat conservation and protection program, for example, a local or regional Habitat Conservation Plan (HCP) or Natural Community Conservation Program (NCCP).
- Reviewing and conforming other elements of the general plan that deal with conservation of natural and cultural resources to the open space element.

The development of open space policies for the protection of cultural places should be done in consultation with culturally-affiliated tribes. It is important to note that the importance of cultural places is not solely rooted in the land or other physical features or objects related to the land on which the cultural place is located. The sense of “place” is often as important as any physical or tangible characteristic. It may be important to a tribe to preserve a certain non-material aspect of a cultural place, such as views or vantage points from or to the cultural place. Cultural interpretation and importance of the place to the tribe should be taken into consideration, in addition to any potential archaeological importance of the place. With this in mind, local governments should be prepared to consider creative solutions for preservation and protection of cultural places.

Neither Government Code §65560(b)(5) nor Government Code §65562.5 mandate local review or revision of the existing open space element of the general plan to inventory and/or protect cultural places. However, local governments should consider doing so in future updates of or comprehensive revisions to the open space element.
XI. Additional Resources

In addition to the information provided in the 2005 Supplement to the *General Plan Guidelines*, local governments may wish to investigate additional resources that can provide more detailed information about Native American people, cultural places, tribal governments, consultation, confidentiality, conservation easements, and other issues related to SB 18. Sources of additional information include federal and state government agencies that have previous experience with tribal consultations, colleges and universities, private organizations and foundations, and the literature and web sites associated with these groups. Although it is not intended to be a comprehensive list, some potentially useful resources are included below.

It is important that local governments keep in mind that Native American tribes are often the best source of information concerning a cultural place's location and characteristics. Local governments are encouraged to seek this information, if available, directly from the tribes themselves.

**State Agencies**

**California Native American Heritage Commission (NAHC)**

The NAHC is the state commission responsible for advocating preservation and protection of Native American human remains and cultural resources. NAHC maintains confidential records concerning places of special religious or social significance to Native Americans, including graves and cemeteries and other cultural places. The NAHC reviews CEQA documents to provide recommendations to lead agencies about consulting with tribes to mitigate potential project impacts to these sites.

The NAHC maintains a list of California tribes and the corresponding contacts that local governments should use for the purpose of meeting SB 18 consultation requirements.

The NAHC web site also provides a number of links to information about federal and state laws, local ordinances and codes, and cultural resources in relation to Native Americans.

Native American Heritage Commission
915 Capitol Mall, Room 364
Sacramento, CA 95814
Phone: (916) 653-4082
Fax: (916) 657-5390
[http://www.nahc.ca.gov](http://www.nahc.ca.gov)
California Office of Historic Preservation (OHP)
California Historical Resources Information System (CHRIS)
Pursuant to state and federal law, the California Office of Historic Preservation (OHP) administers the California Historical Resources Information system (CHRIS). The CHRIS is organized by county and managed by regional information centers (posted on the OHP website). These CHRIS centers house records, reports, and other documents relating to cultural and archaeological resources, and provide information and recommendations regarding such resources on a fee-for-service basis. Local governments may enter into agreements with CHRIS information centers to establish procedures and protocols for requesting searches of historical resource records.

The OHP also provides assistance to local governments to encourage direct participation in historic preservation. OHP provides technical assistance to local governments including training for local commissions and review boards, drafting of preservation plans and ordinances, and developing archaeological and historical surveys.

Office of Historic Preservation
P.O. Box 942896
Sacramento, CA 94296-0001
Phone: (916) 653-6624
Fax: (916) 653-9824
http://www.ohp.parks.ca.gov

California Department of Conservation
Division of Land Resource Protection (DLRP)
The DLRP works with landowners, local governments, and researchers to conserve productive farmland and open spaces.

California Department of Conservation
Division of Land Resource Protection
801 K Street, MS 18-01
Sacramento, CA 95814-3528
Phone: (916) 324-0850
http://www.consrv.ca.gov/DLRP/index.htm

California Department of Housing and Community Development
California Indian Assistance Program (CIAP)
The California Indian Assistance Program’s primary role is to assist tribal governments with obtaining and managing funds for community development and government enhancement. CIAP’s 2004 Field Directory of the California Indian Community is a good reference for California Native American tribes, including location of Indian lands, federal recognition status of tribes, history of laws affecting tribes, and other programs and agencies involved in tribal relationships.
2005 Supplement to *General Plan Guidelines*

California Indian Assistance Program  
1800 Third Street, Room 365  
Sacramento, CA 95814  
Phone: (916) 445-4727  
[http://www.hcd.ca.gov/ca/ciap/](http://www.hcd.ca.gov/ca/ciap/)

**California Department of Transportation (DOT)**  
**Native American Liaison Branch**  
The California DOT administers most of its projects with some federal funding and is therefore subject to Section 106 consultation requirements under NHPA. The department has a Native American Liaison Branch (NALB), with headquarters in Sacramento and Native American Liaisons in each of its twelve districts. The NALB web site contains policy statements and links to other useful resources.

- Office of Regional and Interagency Planning  
  Native American Liaison Branch  
  1120 N Street, MS 32  
  Sacramento, CA 95814  
  Phone: (916) 651-8195  
  Phone: (916) 654-2389  
  Fax: (916) 653-0001  
  [http://www.dot.ca.gov/hq/tpp/offices/orip/na/native_american.htm](http://www.dot.ca.gov/hq/tpp/offices/orip/na/native_american.htm)

**Federal Agencies**

**Federal Highway Administration – AASHTO (American Association of State Highway and Transportation Officials) Center for Environmental Excellence**  
The AASHTO Center for Environmental Excellence provides a web site designed to provide tools for Section 106 of the National Historical Preservation Act (NHPA) tribal consultation. This site contains documents and links to web sites that address key aspects of tribal consultation relevant to SB 18. Information also includes federal, tribal, and state policies and protocols, case law, and best practices as implemented by federal and state agencies and tribes.  
[http://environment.transportation.org/environmental_issues/tribal_consultation/overview.htm](http://environment.transportation.org/environmental_issues/tribal_consultation/overview.htm)

**U.S. Army Corps of Engineers**  
The U.S. Army Corps of Engineers has lasting and positive relations with many tribal governments. The “Tribal Affairs and Initiatives” section of their web site provides information regarding the U.S. Army Corps of Engineers’ approach to tribal consultation and preservation of cultural resources.  
USDA Forest Service
The Forest Service has extensive experience in consulting with Native American tribes. The Forest Service’s Forest Service National Resource Book on American Indian and Alaska Native Relations is an excellent resource book on tribal beliefs and practices, tribal consultation, and laws affecting Native Americans. The Forest Service’s Report of the National Tribal Relations Program Implementation Team (June 2003) reviews relationships between the Forest Service and tribes, identifying pervasive problems and concerns and making recommendations to improve the effectiveness of the program at maintaining long-term collaborative relationships with tribal governments.

USDA Forest Service
Regional Office of Tribal Relations
Sonia Tamez
1323 Club Drive
Vallejo, CA 95492
Phone: (707) 562-8919
www.r5.fs.fed.us

USDA National Sustainable Agriculture Information Service (ATTRA)
The ATTRA provides information and other technical assistance to farmers, ranchers, Extension agents, educators, and others involved in sustainable agriculture in the United States. The ATTRA publication, Conservation Easements, Resource Series (2003), provides an overview of what holding and selling conservation easements entail.

ATTRA - National Sustainable Agriculture Information Service
PO Box 3657
Fayetteville, AR 72702
Phone: (800) 346-9140
Fax: (479) 442-9842
http://attra.ncat.org/

USDA Natural Resources Conservation Service (NRCS)
The mission of the NRCS is to address natural resource conservation on private lands. The website contains links to various conservation technical resources and to additional contact information for area offices and service centers.

California NRCS State Office
430 G Street #4164
Davis, CA 95616-4164
Phone: (530) 792-5600
Fax: (530) 792-5610
http://www.ca.nrcs.usda.gov/

U.S. Department of Interior – Bureau of Indian Affairs
The Bureau of Indian Affairs (BIA) is responsible for the administration and management of 55.7 million acres of land held in trust by the United States for American Indians, Indian tribes, and Alaska Natives. Developing forestlands, leasing assets on these lands, directing agricultural
programs, protecting water and land rights, developing and maintaining infrastructure, and economic development are all agency responsibilities. The BIA web site includes links to other federal agencies, inter-tribal organizations, environmental organizations, and cultural resources.

Bureau of Indian Affairs  
Phone: (202) 208-3710  

**U.S. Department of Interior – Bureau of Land Management**  
The Bureau of Land Management manages 261 million acres of land and has staff whose duties include coordination and consultation with Native Americans. The Bureau publishes *Native American Coordination and Consultation, Manual Section 8160 with Handbook H-8160-1*. The handbook is devoted to providing general guidance for tribal consultation, and can be found online at: http://www.blm.gov/nhp/efoia/wo/handbook/h8160-1.html.

Bureau of Land Management  
California State Office  
2800 Cottage Way, Suite W-1834  
Sacramento, CA 95825-1886  
Phone: (916) 978-4400  
Phone: (916) 978-4416  
TDD: (916) 978-4419  
http://www.ca.blm.gov/

**U.S. Department of Interior – National Park Service**  
The following National Park Service web site specifically focuses on cultural resource preservation. The site includes links to tools for cultural resource preservation, different areas of cultural resource protection and different offices of the National Park Service that handle cultural preservation issues. Included among these offices is the American Indian Liaison Office, the web site of which contains a number of information resources that are potentially useful to local governments learning how to consult with Native American tribes on land use policy.  
http://www.cr.nps.gov

**U.S. Department of Interior – Office of Collaborative Action and Dispute Resolution**  
This web site provides links to federal agencies’ policies on tribal consultation:  

**Colleges and Universities**  
**Humboldt State University**  
The Center for Indian Community Development (CICD)  
The CICD primarily focuses on Indian language education, but also acts in the capacity of a liaison between Native American tribes and the community. The CICD includes a cultural resource facility where information about Native American burial grounds and cultural resource monitoring can be found. The CICD offers useful publications on tribal governments and cultural approaches to environmental protection of Native American lands on its web site.
University of California, Los Angeles
American Indian Studies Center (AISC)
The AISC has spent a number of years conducting research on issues affecting Native American Indian communities. The center has sponsored conferences on issues including California tribes, repatriation, federal recognition, and Indian gaming. The AISC offers a number of publications on issues ranging from Contemporary Native American Issues and Native American Politics to Native American Theater and Native American Literature.

UCLA American Indian Studies Center
3220 Campbell Hall
Los Angeles, CA 90095-1548
Phone: (310) 825-7315
Fax: (310) 206-7060
http://www.aisc.ucla.edu/

University of California, Los Angeles School of Law
Native Nations Law and Policy Center (NNLPC)
The mission of NNLPC at UCLA Law is to support Native nations throughout the United States, with a special focus on California tribes, in developing their systems of governance and in addressing critical public policy issues and to apply the resources of state-supported education together with tribal expertise to address contemporary educational needs for California Tribes. The Research and Publications division secures grants, carries out research, and sponsors conferences and roundtables drawing together scholars, tribal leaders, and federal/state policymakers.

UCLA School of Law
P.O. Box 951476
Los Angeles, CA 90095-1476
Phone: (310) 825-4841
http://www.law.ucla.edu/students/academicprograms/nativenations/nnlpc.htm

Private Organizations and Foundations
American Farmland Trust (AFT)
Since its founding in 1980, the AFT has helped to achieve permanent protection for over a million acres of American farmland. The AFT focuses its strategies on protecting land through publicly funded agricultural conservation easement programs and encouraging conservation practices in community planning and growth management.
2005 Supplement to General Plan Guidelines

American Farmland Trust
1200 18th Street NW
Washington, D.C. 20036
Phone: (202) 331-7300
Fax: (202) 659-8339
http://www.farmland.org/

Inter-Tribal Council of California, Inc. (ITCC)
The key role of the Inter-Tribal Council of California (ITCC) is to assist in bridging relationships between California tribal governments and other organizations, including local government agencies. The ITCC offers workshops on Native American cultural proficiency and tribal governments for the purpose of educating non-Native Americans on how to effectively communicate with tribal governments, in addition to other training and technical assistance. The ITCC is experienced in assisting the development of Memoranda of Understanding and Agreement, protocols, and educational outreach materials.

Inter-Tribal Council of California, Inc.
2755 Cottage Way, Suite 14
Sacramento, CA 95825
Phone: (916) 973-9581
Fax: (916) 973-0117

Land Trust Alliance (LTA)
The Land Trust Alliance promotes voluntary land conservation by offering training, conferences, literature, reports, and other information on land conservation. The LTA has several publications discussing conservation techniques. Their web site addresses different conservation options for landowners and includes questions and answers about conservation easements, land donation, and bargain sale of land.

Land Trust Alliance
1331 H Street NW, Suite 400
Washington D.C. 20005-4734
Phone: (202) 638-4725
Fax: (202) 638-4730
http://www.lta.org/conserve/options.htm

Native American Land Conservancy
The Native American Land Conservancy is a nonprofit corporation formed for the conservation and preservation of Native American sacred lands.

Native American Land Conservancy
Kurt Russo, Executive Director
PO Box 1829
Indio, CA 92202
Phone: (800) 6770-6252
The Nature Conservancy (TNC)
The Nature Conservancy is a non-profit organization that works with communities, businesses, and individuals to preserve lands with natural and cultural resources.

The Nature Conservancy
4245 North Fairfax Drive, Suite 100
Arlington, VA 22203-1606
http://nature.org/

Southern California Tribal Chairmen's Association (SCTCA)
The Southern California Tribal Chairmen's Association (SCTCA) is a multi-service non-profit corporation established in 1972 for a consortium of 19 Federally recognized Indian tribes in Southern California. The Primary goals and objectives of SCTCA are the health, welfare, safety, education, culture, economic and employment opportunities for its tribal members. A board of directors comprised of tribal chairpersons from each of its member tribes governs SCTCA.

Southern California Tribal Chairmen's Association
Denis Turner
Executive Director
Phone: (760) 742-8600 x100
http://www.sctca.net/

Trust for Public Land (TPL)
The Trust for Public Land (TPL) is a national, nonprofit, land conservation organization that conserves land for people to enjoy as parks, community gardens, historic sites, rural lands, and other natural places, ensuring livable communities for generations to come. Since 1972, TPL has worked with willing landowners, community groups, and national, state, and local agencies to complete more than 2,700 land conservation projects in 46 states, protecting nearly 2 million acres.

Trust for Public Land National Office
116 New Montgomery St., 4th Floor
San Francisco, CA 94105
Phone: (415) 495-4014
Fax: (415) 495-4103
http://www.tpl.org
Exhibit A: Sample Request to the NAHC for Tribal Contact Information

LOCAL GOVERNMENT
TRIBAL CONSULTATION LIST REQUEST
NATIVE AMERICAN HERITAGE COMMISSION
915 CAPITOL MALL, ROOM 364
SACRAMENTO, CA 95814
(916) 653-4082
(916) 657-5390 - Fax

Project Title: ________________________________________________

Local Government/Lead Agency: _____________________________
Contact Person: ____________________
Phone: _____________________________

Street Address: _____________________________
Fax: _____________________________

City: _____________________________ Zip: ___________

Project Location:

County: _____________________________ City/Community: _____________________________

Local Action Type:

___ General Plan  ___ General Plan Element  ___ Specific Plan

___ General Plan Amendment  ___ Specific Plan Amendment

___ Pre-planning Outreach Activity

Project Description:

NAHC Use Only

Date Received: _______________
Date Completed _______________

Native American Tribal Consultation lists are only applicable for consulting with California Native American tribes per Government Code Section 65352.3.
Water Quality

California Nonpoint Source Encyclopedia
Prepared for State Water Resources Control Board by Tetra Tech, Inc. ............................................................... 1271

Californians Without Safe Water: A 2005 Update
By Monique Wilber..................................................................................................................................... 1527

Water Quality, California, 2004
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Prepared for State Water Resources Control Board by Tetra Tech, Inc
The contents of this document do not necessarily reflect the views and policies of the USEPA or the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

To ensure that the NPS Encyclopedia includes the most pertinent and current information available, it will be updated semiannually. Comments and suggestions for the addition of new material will be accepted on a continuous basis. Please forward any questions, comments, or suggested additions to Diane Edwards by e-mail (edwad@swrcb.ca.gov) or phone (916-341-5908).
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1. INTRODUCTION

The goal of this guidance document is to provide the best, most relevant information to State agencies, regional boards, local agencies, and nonpoint source (NPS) practitioners to assist them in identifying and implementing practices to protect high-quality waters and restore impaired waters. This guidance document is not applicable to any facilities that are considered point sources under the Clean Water Act, including confined animal facilities that are Concentrated Animal Feeding Operations (CAFOs) as defined by USEPA. The guidance is organized around the six NPS categories identified in the Plan for California's Nonpoint Source Pollution Control Program of 2000: agriculture, forestry, urban areas, marinas and recreational boating, hydromodification, and wetlands/riparian areas/vegetated treatment systems. It supports the plan's goal of implementing the 61 NPS management measures by 2013. It also supports the implementation of NPS total maximum daily loads (TMDLs), as well as the development of TMDL implementation plans and watershed plans. A companion set of tools will also be available through the Internet to assist users in identifying potential management practices and estimating the effectiveness of those practices in managing pollution.

1.1 Regulatory Background

California’s legal framework for implementing the NPS program is based on two primary federal laws—the Clean Water Act and Coastal Zone Management Act (CZMA)—and State and local law. In California, the Porter-Cologne Act is the principal State law governing water quality in California, and it provides the primary back-up authority to implement the NPS management measures. However, other State and local authorities are also critical components of the legal framework that address NPS pollution in California. In addition to the Porter-Cologne Act, this section describes the California Coastal Act, the California Environmental Quality Act (CEQA), and the California planning, zoning, and development laws. Additional details on these and other authorities that are part of this framework are identified in the Plan for California’s Nonpoint Source Pollution Control Program Volume II: California Management Measures for Polluted Runoff (http://www.swrcb.ca.gov/nps/cammpmr.html). Details on the State Water Resource Control Board’s and California Coastal Commission’s statutory authority for addressing nonpoint sources are included in Appendix B of the Plan for California’s Nonpoint Source Pollution Control Program Volume I: Nonpoint Source Program Strategy and Implementation Plan (1998-2013), entitled Legal Opinions (http://www.swrcb.ca.gov/nps/docs/planvol1.doc).
1.1.1 Federal Laws

The Federal Water Pollution Control Act, known as the Clean Water Act (33 United States Code [USC] sections 1251 et seq.), is the principal federal statute for water quality protection. In California, the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs) implement many of the Clean Water Act’s provisions. The Clean Water Act requires the State to adopt water quality standards and to submit those standards for approval by the U.S. Environmental Protection Agency (USEPA). For point source discharges to surface water, the Clean Water Act authorizes USEPA or approved states to administer the National Pollutant Discharge Elimination System (NPDES) program. Clean Water Act section 303(d) requires states to list surface waters not attaining (or not expected to attain) water quality standards after the application of technology-based effluent limits, and states normally must prepare and implement a TMDL for all waters on the Clean Water Act section 303(d) list. The Clean Water Act also establishes a loan program—the State Revolving Fund (SRF)—for the construction of water quality projects, including NPS projects.

In the 1987 Clean Water Act amendments, Congress added Clean Water Act section 319 (33 USC section 1329), which required states (1) to develop assessment reports that described the states’ NPS problems, (2) to establish management programs to address these problems, and (3) to provide funding to support implementation of the programs. California’s Nonpoint Source Management Plan (SWRCB, 1988) outlined a general approach to address persistent NPS problems using education and outreach, financial and technical assistance, and regulatory authorities when necessary. To enhance activities to address NPS pollution, states are currently encouraged to upgrade their NPS programs. In 1996, USEPA issued Clean Water Act section 319 program guidance that identified “nine key elements” that must be addressed to receive USEPA approval for upgraded NPS plans. Pursuant to the 1998 Clean Water Action Plan, states with upgraded NPS programs will receive increased funding based on a federal appropriation for state NPS programs above $100 million. For California to receive additional funding in fiscal year 2000 and beyond, USEPA must certify that California’s NPS Program has been upgraded consistent with the nine key elements.

The CZMA of 1972 (16 USC sections 1451 et seq.) established a national framework for effective management, protection, development, and beneficial use of the coastal zone. Pursuant to the CZMA, California prepared the California Coastal Management Program that was approved by the National Oceanic and Atmospheric Administration (NOAA). The bulk of California’s coast is within the jurisdiction of the California Coastal Commission pursuant to the Coastal Act of 1976 (Public Resources Code [PRC] sections 30000 et seq.), while the San Francisco Bay Conservation and Development Commission has jurisdiction in San Francisco Bay pursuant to the McAteer-Petris Act (MPA) (Government Code sections 66600 et seq.). The State Coastal Conservancy is a third partner agency in the California Coastal Management Program.

Recognizing that the CZMA did not specifically mention water quality, in 1990 Congress amended CZMA section 306(d)(16) (16 USC section 1455[d][16]) and added section 6217 (16 USC section 1455b) to focus on NPS pollution problems and the protection of coastal waters. Coastal Zone Act Reauthorization Amendments (CZARA) section 6217 requires state coastal zone management agencies, in coordination with state water quality agencies, to develop and implement management measures to restore and protect coastal waters from adverse impacts of NPS pollution. Similarly, CZMA section 306(d)(16) (16 USC section 1455[d][16]) requires that state coastal zone management programs contain enforceable policies and mechanisms to implement applicable requirements of CZARA section 6217. To achieve these goals, states were directed to coordinate and integrate their existing coastal zone management and water quality plans and programs, including the states’ NPS management plans.
1.1.2 Porter-Cologne Water Quality Control Act

The Porter-Cologne Act is the principal law governing water quality regulation in California. It establishes a comprehensive program to protect water quality and the beneficial uses of water. The Porter-Cologne Act applies to surface waters, wetlands, and ground water and to both point and nonpoint sources of pollution. Pursuant to the Porter-Cologne Act (California Water Code section 13000 et seq.), the policy of the State is as follows:

- That the quality of all the waters of the State shall be protected,
- That all activities and factors affecting the quality of water shall be regulated to attain the highest water quality within reason, and
- That the State must be prepared to exercise its full power and jurisdiction to protect the quality of water in the State from degradation.

The Porter-Cologne Act established nine RWQCBs and the SWRCB, which are charged with implementing its provisions and which have primary responsibility for protecting water quality in California. The SWRCB provides program guidance and oversight, allocates funds, and reviews RWQCB decisions. In addition, the SWRCB allocates rights to the use of surface water. The RWQCBs have primary responsibility for individual permitting, inspection, and enforcement actions within each of nine hydrologic regions. The SWRCB and RWQCBs have numerous NPS-related responsibilities, including problem monitoring and assessment, planning, financial assistance, and regulatory and non-regulatory management.

The RWQCBs regulate discharges under the Porter-Cologne Act primarily through issuance of NPDES permits for point source discharges and waste discharge requirements for NPS discharges. Anyone discharging or proposing to discharge materials that could affect water quality (other than to a community sanitary sewer system regulated by an NPDES permit) must file a report of waste discharge. The SWRCB and the RWQCBs can make their own investigations or may require dischargers to carry out water quality investigations and report on water quality issues. The Porter-Cologne Act provides several options for enforcing WDRs and other orders, including cease and desist orders, cleanup and abatement orders, administrative civil liability orders, civil court actions, and criminal prosecutions.

The Porter-Cologne Act also implements many provisions of the Clean Water Act, such as the NPDES permitting program. Section 401 of the Clean Water Act gives the SWRCB the authority to review any proposed federally permitted or federally licensed activity that may impact water quality and to certify, condition, or deny the activity if it does not comply with State water quality standards. If the SWRCB imposes a condition on its certification, those conditions must be included in the federal permit or license.

Except for dredge and fill activities, injection wells, and solid waste disposal sites, WDRs may not "specify the design, location, type of construction or particular manner in which compliance may be had" (Porter-Cologne Act section 13360). Thus, WDRs ordinarily specify the allowable discharge concentration or load or the resulting condition of the receiving water, rather than the manner by which those results are to be achieved. However, the RWQCBs may impose discharge prohibitions and other limitations on the volume, characteristics, area, or timing of discharges and can set discharge limits such that the only practical way to comply is to use management practices. RWQCBs can also waive WDRs for a specific discharge or category of discharges on the condition that management measures identified in a water quality management plan approved by the SWRCB or RWQCB are followed.

The Porter-Cologne Act also requires adoption of water quality control plans that contain the guiding policies of water pollution management in California. A number of statewide water quality control plans
have been adopted by the SWRCB. In addition, regional water quality control plans, commonly referred to as basin plans, have been adopted by each of the RWQCBs. All basin plans identify the existing and potential beneficial uses of waters of the State and establish water quality objectives to protect these uses. The basin plans also contain implementation, surveillance, and monitoring plans. Water quality control plans include enforceable prohibitions against certain types of discharges, including those that may pertain to nonpoint sources. Basin plans have been adopted for each of the nine regions.

Portions of water quality control plans are also subject to review by USEPA. When approved by USEPA, the water quality objectives and beneficial use designations become water quality standards under the Clean Water Act. In most cases, water quality objectives contained in a water quality control plan are not directly enforceable unless implemented through WDRs or water right permits.

1.1.3 California Coastal Act

The State Legislature enacted the California Coastal Act (PRC section 30000 et seq.) to provide for the conservation and planned development of the State’s coastline. The Coastal Act mandates the protection and restoration of coastal waters pursuant to several sections in the PRC. Mandated activities include the following:

- To carry out a public education program to promote coastal conservation.
- To maintain, enhance, and, where feasible, restore marine resources.
- To maintain and, where feasible, restore biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes through, among other means, minimizing adverse effects of wastewater discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface water flow, encouraging wastewater reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.
- To protect against spillage of crude oil, gas, petroleum products, or hazardous wastes.
- To limit the alteration of wetlands, coastal waters, and estuaries and provide for feasible mitigation measures to minimize adverse environmental effects.
- To phase out or upgrade, where feasible, existing marine structures causing water stagnation contributing to pollution problems and fish kills.
- To limit hydromodification of rivers and streams. Channelization, dams, and other substantial alterations of rivers and streams must incorporate best mitigation measures feasible.
- To protect environmentally sensitive habitat areas (ESHAs). To site and design new development in areas adjacent to ESHAs to prevent significant adverse impacts.
- To protect long-term productivity of soils and timberlands.
- To site and design new development so as to not have significant adverse impacts either individually or cumulatively on coastal resources.
- To minimize alteration of natural landforms.
To ensure that new development is stable, has structural integrity, and does not contribute significantly to erosion.

To control impacts of dredging in specified port areas.

To minimize harmful effects on coastal waters, including water quality, from fill within ports.

To locate, design, and construct port-related development to minimize substantial environmental impacts and protect beneficial uses.

In carrying out the mandates of the Coastal Act, the California Coastal Commission (CCC) certifies local coastal programs (LCPs) prepared by local governments (PRC section 30500). The CCC also certifies plans prepared by port districts (PRC section 30711 et seq.), colleges and universities (PRC section 30605), and proponents of public works projects (PRC section 30605). In addition, the CCC approves coastal development permits (CDPs), energy projects, and federal (federally approved, conducted, or funded) projects consistent with Coastal Act policies. The Coastal Act also contains several means to deter and discipline violators of its provisions. In order to prevent imminent or further damage of coastal resources, the Executive Director of the SWRCB or the CCC can issue a cease and desist order to any party that is undertaking a development without a permit or in a manner inconsistent with the terms of a previously issued permit (PRC sections 30809 and 30810). The CCC can also order the restoration of a site (PRC section 30811). Civil liability fines for violations of the Coastal Act are specified in PRC sections 30820, 30821.6, and 30822. In practice, the CCC protects water quality primarily through (1) managing coastal development that generates runoff or creates spills, (2) assisting local coastal governments and other agencies to address land-use and development activities that may produce NPS pollution, and (3) implementing educational and technical assistance programs.

1.1.4 California Environmental Quality Act

California is one of 20 states with an environmental impact assessment law, called the California Environmental Quality Act (CEQA), which is modeled after the National Environmental Policy Act (NEPA). The SWRCB, RWQCBs, and all State and local government agencies must comply with CEQA. CEQA applies to discretionary activities proposed to be carried out by government agencies, including approval of permits and other entitlements. CEQA has six objectives:

1. To disclose to decision-makers and the public the significant environmental effects of proposed activities,

2. To identify ways to avoid or reduce environmental damage,

3. To prevent environmental damage by requiring implementation of feasible alternatives or mitigation measures,

4. To disclose to the public reasons for agency approvals of projects with significant environmental effects,

5. To foster interagency coordination, and

6. To enhance public participation.

CEQA sets forth procedural requirements to ensure that the objectives are accomplished and also contains substantive provisions requiring agencies to avoid or mitigate, when feasible, impacts disclosed in an
Environmental Impact Report. In addition, CEQA sets forth a series of broad policy statements encouraging environmental protection. These policies have led the courts to interpret CEQA “so as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language” (Friends of Mammoth v. Board of Supervisors [1972] 8 Cal 3d 247, 259, 104 Cal. Rptr. 761).

1.1.5 Planning, Zoning, and Development Laws
The legal framework within which California cities and counties exercise local planning and land use functions, which can play a critical role in addressing NPS pollution, is provided in the California Planning and Zoning Law (Government Code sections 65000 et seq.) and the Subdivision Map Act (SbMA) (Government Code sections 66410 et seq.), as well as in the Coastal Act.

Under State planning law, each city or county must adopt a comprehensive, long-term general plan for the physical development of the city or county and any land outside its jurisdiction that bears relation to its planning. Pursuant to Government Code section 65302, general plans must contain seven elements: (1) land use, (2) circulation, (3) housing, (4) conservation, (5) open space, (6) noise, and (7) safety. The following elements are the most relevant to NPS pollution prevention and control:

- **Land Use.** Designates categories such as housing, industry, and natural resources, including density and intensity of use.

- **Conservation.** Applies to conservation, development, and use of natural resources (e.g., soils, forests, rivers and other water bodies, and harbors). May also cover watershed protection, land or water reclamation, prevention or control of the pollution of streams and other coastal waters, regulation of land uses along stream channels and in other areas required to implement the conservation plan (e.g., buffer areas), to control or correct soil erosion, and for flood control.

- **Open Space.** Applies to the preservation of natural resources, including fish and wildlife habitat, rivers, streams, bays and estuaries, and open space.

- **Circulation.** Plans infrastructure, including water, sewage, and storm drainage.

While the general plan is a long-range look at the future of a community, a zoning ordinance spells out the immediate allowable uses for each property in the community. Each property in the community is assigned a “zone” listing the kinds of uses that will be allowed on that land (e.g., single family residential, multi-family residential, neighborhood commercial, light industrial, agricultural) and setting development standards (e.g., minimum lot size, maximum building height, minimum front-yard depth). The distribution of residential, commercial, industrial, and other zones is based on the pattern of land uses established in the community’s general plan. Zoning is adopted by ordinance and carries the weight of local law. All local governments use some form of permitting process whereby a permit is issued for a specific project and can be conditioned based on compliance with the zoning ordinance.

Subdivision regulation, like zoning, is an exercise of police power and is a principal instrument for implementing a general plan. The SbMA (Government Code sections 66410 et seq.) sets forth other mandates that must be followed for subdivision processing.

The local government’s corporate and police powers and zoning and subdivision ordinances are tools commonly used to implement general plans. Preferential assessment of real property can also offer landowners an economic incentive for keeping their land in agricultural, timber, or open space uses. This can serve to implement the land use, open space, and conservation elements of a general plan by reserving areas designated for agriculture, timber, open space, scenic resources, and natural resource use.
The Coastal Act also requires cities and counties that are located wholly or partially in the coastal zone to have an “eighth element” (the local coastal program or LCP) for that portion of the local government’s jurisdiction in the coastal zone. When an LCP is certified by the CCC as being consistent with the goals and policies of the Coastal Act, coastal permit authority for that area is delegated to the local government. However, development in State tidelands, submerged lands, and public trust lands still requires a permit from the CCC, and certain types of local government decisions on coastal permits made under certified LCPs may be appealed to the CCC.

1.1.6 SWRCB Antidegradation Policy

A key policy of California’s water quality program is the State’s Antidegradation Policy. This policy, formally known as the Statement of Policy with Respect to Maintaining High Quality Waters in California (SWRCB Resolution No. 68-16), restricts degradation of surface and ground waters. In particular, this policy protects water bodies where existing quality is higher than necessary for the protection of beneficial uses.

Under the Antidegradation Policy, any actions that can adversely affect water quality in all surface and ground waters must (1) be consistent with maximum benefit to the people of the State, (2) not unreasonably affect present and anticipated beneficial use of the water, and (3) not result in water quality less than that prescribed in water quality plans and policies. Furthermore, any actions that can adversely affect surface waters are also subject to the Federal Antidegradation Policy (40 Code of Federal Regulations [CFR] section 131.12) developed under the Clean Water Act.

1.2 Structure of Document

The California Nonpoint Source Encyclopedia is designed to facilitate a general understanding of NPS management techniques and to provide quick access to essential information from a variety of sources. Direct links to Internet resources will enhance the usefulness of the guidance. The guidance is structured according to the 61 management measures so that the user can easily identify areas of interest, review the measures, and access additional information for selected topics. See Table 1-1 for a complete list of management measures by NPS category.

Fact sheets prepared for each of the 61 management measures provide a brief discussion of the essential elements and intent of each management measure and useful information sources and references. Each fact sheet contains the following sections:

- **Programs:** A description of several State and federal programs related to implementation of the management measure. For example, the fact sheets prepared for management measures related to urban runoff would include a discussion of the SWRCB and RWQCBs’ NPDES storm water program, as well as the planning and land use permitting functions of other State agencies such as the California Coastal Commission.

- **Management Practices:** A list of specific practices that can be used to achieve the goals outlined in each management measure. This information includes a description of management practices or categories of practices and how they will contribute to meeting each management measure, as well as their applicability to situations in California and their cost-effectiveness in different climatic and land use settings. This information summarizes some of the best information from various documents and data sources, both national and state-specific.
• **Information Resources:** A list of some of the most useful “additional resources” such as Internet sites, technical reports, guidance manuals, and other references. These resources are intended to assist the user in understanding and implementing management practices to meet the management measure.

• **Case Studies:** Examples of successful implementation of the management measure or one or more management practices in California.

• **References:** Information resources that were used to compile the information contained in the fact sheet.

Table 1-1 provides a summary list of NPS categories and the California management measures that fall under each category.

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Table 1-1. NPS Categories and Management Measures

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## NPS Category | Management Measures
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4.1D | Shoreline Stabilization
4.1E | Storm Water Runoff
4.1F | Fueling Station Design
4.1G | Sewage Facilities
4.1H | Waste Management Facilities
4.2 | Operation and Maintenance
4.2A | Solid Waste Control
4.2B | Fish Waste Control
4.2C | Liquid Material Control
4.2D | Petroleum Control
4.2E | Boat Cleaning and Maintenance
4.2F | Maintenance of Sewage Facilities
4.2G | Boat Operation
4.3 | Education/Outreach
4.3A | Public Education/Outreach

## Hydromodification

| 5.1 | Channelization and Channel Modification
5.1A | Physical and Chemical Characteristics of Surface Waters
5.1B | Instream and Riparian Habitat Restoration
5.2 | Dams
5.2A | Erosion and Sediment Control
5.2B | Chemical and Pollutant Control
5.2C | Protection of Surface Water Quality and Instream and Riparian Habitat
5.3 | Streambank and Shoreline Erosion
5.3A | Eroding Streambanks and Shorelines
5.4 | Education/Outreach
5.4A | Educational Programs

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| 6A | Protection of Wetlands and Riparian Areas
6B | Restoration of Wetlands and Riparian Areas
6C | Vegetated Treatment Systems
6D | Education/Outreach

### 1.2.1 References


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2. MANAGEMENT MEASURE CATEGORIES

2.1 Agriculture

2.1.1 Introduction
The California State Water Resources Control Board (SWRCB), California Coastal Commission (CCC), and other state agencies have identified seven management measures to address agricultural nonpoint source (NPS) pollution of State waters. The management measures consist of a suite of plans, practices, technologies, operating methods, or other alternatives that may be used in combination to control NPS pollution. Associated with each management measure are management practices that are designed to reduce the quantities of pollutants entering receiving waters. Many of the practices listed under each management measure were approved for use by the California Natural Resources Conservation Service (NRCS). Some practices are recommended by the U.S. Department of Agriculture (USDA) NRCS as components of Resource Management Systems (RMSs). RMSs, also known as conservation planning, are whole-farm plans that incorporate economic, social, and ecological considerations to meet the demands of crop and animal production and long-term environmental sustainability. RMSs contain pollution control criteria for soil, air, water, plant, animal, and human resources, which are described in the USDA NRCS Field Office Technical Guide. Not all components of RMSs are included in the management measures and practices—only those that are related to water quality. The fact sheet prepared for each management measure informs readers of the programs, resources, and case studies specific to California and the management measure.

The NPS pollutants typically associated with agriculture are nutrients, animal waste, sediments, and pesticides. Agricultural NPS pollution enters receiving waters by direct runoff to surface waters or seepage to ground water. Runoff of nutrients can result from excessive application of fertilizers and animal waste to land, and from improper storage of animal waste. Farming activities can cause excessive erosion, which results in sediment entering receiving waters. Improper use and overapplication of pesticides causes pesticide pollution. Improper grazing management can cause erosion, soil compaction, and excessive nutrients, all of which impair sensitive areas. Overapplication of irrigation water can cause runoff of sediments and pesticides to enter surface water or seep into ground water. Sediment, pesticides, and excess nutrients all affect aquatic habitats by causing eutrophication, turbidity, temperature increases, toxicity, and decreased oxygen.

Programs established to control NPS pollution from agriculture in California include joint efforts by local, State, and federal agencies. The SWRCB and the CCC oversee the statewide program, with assistance from the Department of Pesticide Regulation for pesticide pollution and the Department of Water Resources for irrigation water management. Local governments administer programs for general planning and local coastal plans. The California NRCS and the University of California Cooperative Extension Service provide technical and financial services for farmers. Resource Conservation Districts also provide guidance, training, and technical assistance. The programs administered by these various agencies are
listed under the Programs heading in each fact sheet; sources of information specific to each management measure are listed under Information Resources.

The California Management Measures for Polluted Runoff defines the seven agriculture management measures as follows:

- **1A. Erosion and Sediment Control.** Management Measure 1A addresses NPS problems associated with soil erosion and sedimentation. Where erosion and sedimentation from agricultural lands affects coastal waters and/or water bodies listed as impaired by sediment, landowners must design and install or apply a combination of practices to reduce solids and associated pollutants in runoff during all but the larger storms. Alternatively, landowners may apply the erosion component of an RMS as defined in the USDA NRCS Field Office Technical Guide, which contains standards and specifications for installing these practices.

- **1B. Facility Wastewater and Runoff from Confined Animal Facilities That Are Not CAFOs.** Pursuant to Management Measure 1B, facility wastewater and contaminated runoff from confined animal facilities that are not CAFOs must be contained at all times. Storage facilities should be of adequate capacity to allow for proper wastewater use and should be constructed so they prevent seepage to ground water, and stored runoff and accumulated solids from the facility should be managed through a waste use system that is consistent with Management Measure 1C or removed from the site.

- **1C. Nutrient Management.** Management Measure 1C addresses the development and implementation of comprehensive nutrient management plans for areas where nutrient runoff is a problem affecting coastal waters and/or water bodies listed as impaired by nutrients. Such plans would include a plant tissue analysis to determine crop nutrient needs; crop nutrient budget; identification of the types, amounts, and timing of nutrients necessary to produce a crop based on realistic crop yield expectations; identification of hazards to the site and adjacent environment; soil sampling and tests to determine crop nutrient needs; and proper calibration of nutrient equipment. When manure from confined animal facilities that are not CAFOs is to be used as a soil amendment and/or is disposed of on land, the plan should discuss steps to ensure that subsequent irrigation of that land does not leach excess nutrients to surface or ground water.

- **1D. Pesticide Management.** Management Measure 1D is intended to reduce contamination of surface water and ground water from pesticides. Implementation of this measure will primarily occur through cooperation with the Department of Pesticide Regulation as provided in a Management Agency Agreement with the SWRCB. Elements of this measure include development and adoption of reduced risk pest management strategies (including reductions in pesticide use); evaluation of pest, crop, and field factors; use of Integrated Pest Management (IPM); consideration of environmental impacts in choice of pesticides; calibration of equipment; and use of anti-backflow devices. IPM is a key component of pest control. IPM strategies include evaluating pest problems in relation to cropping history and previous pest control measures, and applying pesticides only when an economic benefit will be achieved. When used, pesticides should be selected based on their effectiveness to control target pests and environmental impacts such as their persistence, toxicity, and leaching potential.

- **1E. Grazing Management.** Management Measure 1E is intended to protect sensitive areas (including streambanks, lakes, wetlands, estuaries, and riparian zones) by reducing direct loadings of animal wastes and sediment. This may include restricting or rotationally grazing livestock in sensitive areas by providing fencing and livestock stream crossings, and by locating salt, shade, and alternative drinking sources away from sensitive areas. Upland erosion can be reduced by, among other methods, (1) maintaining the land consistent with the California Rangeland Water Quality Management Plan or Bureau of Land Management and USDA Forest...
Service activity plans or (2) applying the range and pasture components of a Resource Management System (USDA NRCS Field Office Technical Guide). This may include prescribed grazing, seeding, gully erosion control such as grade stabilization structures and ponds, and other critical area treatment.

- **IF. Irrigation Water Management.** Management Measure 1F promotes effective irrigation while reducing pollutant delivery to surface and ground waters. Pursuant to this measure, irrigation water would be applied uniformly based on an accurate measurement of cropwater needs and the volume of irrigation water applied, considering limitations raised by such issues as water rights, pollutant concentrations, water delivery restrictions, salt control, wetland, water supply, and frost/freeze temperature management. Additional precautions would apply when chemicals are applied through irrigation.

- **1G. Education/Outreach.** The goals of Management Measure 1G are to implement pollution prevention and education programs to reduce NPS pollutants generated by the following activities, where applicable:
  - Activities that cause erosion and loss of sediment on agricultural land and land that is converted from other land uses to agricultural land;
  - Activities that cause discharge from confined animal facilities (excluding CAFOs) to surface waters;
  - Activities that cause excess delivery of nutrients and/or leaching of nutrients;
  - Activities that cause contamination of surface water and ground water from pesticides;
  - Grazing activities that cause physical disturbance to sensitive areas and the discharge of sediment, animal waste, nutrients, and chemicals to surface and ground waters;
  - Irrigation activities that cause NPS pollution of surface waters.

### 2.1.2 General Resources

There are several federal and State agencies and programs that can provide general information to promote sustainable agriculture and prevent NPS pollution from entering receiving waters. The agencies and programs below can provide assistance and information for all seven management measures. Resources specific to each of the seven agriculture management measures can be found on the corresponding fact sheet.

- **University of California Cooperative Extension Service** (http://ucanr.org/CES.CEA.shtml): The Cooperative Extension Service has 50 offices in California with experienced staff to provide technical assistance to landowners on farm management and environmental protection. Local cooperative extension service offices can provide specific, local information on programs and information resources available to address many of the agriculture management measures.

- **California NRCS** (http://www.ca.nrcs.usda.gov/): For local assistance, contact USDA NRCS California State Office, 430 G Street #4164, Davis, CA 95616-4164 (Telephone: 530-792-5600; Fax: 530-792-5790). The California NRCS works with landowners and provides technical and financial assistance to conserve natural resources on private lands. In California, assistance is provided to land users through cooperative partnerships with more than 100 Resource Conservation Districts and other agencies and organizations. Soil and resource conservationists, soil scientists, agronomists, foresters, wildlife biologists, engineers, water quality specialists, information specialists, and other resource management professionals work together to address locally identified and nationally prioritized conservation issues. County USDA NRCS offices can
provide specific, local information on programs and information resource available to address many of agriculture management measures. Use the Web site listed above to locate the USDA NRCS office for each county.

- **California Department of Food and Agriculture, Office of Agriculture and Environmental Stewardship** ([http://www.cdfa.ca.gov/exec/aep/AES_home.htm](http://www.cdfa.ca.gov/exec/aep/AES_home.htm)): This office identifies and prioritizes environmental conservation and protection issues related to agriculture and provides the agricultural community and the general public with accurate and timely information as well as technical support to identify, develop, and implement actions that enhance environmental conservation and protection.

- **California Association of Resource Conservation Districts** ([http://www.carc.org/](http://www.carc.org/)): Resource Conservation Districts (RCDs) are special districts of the State of California, set up under California law to be locally governed agencies with their own locally appointed, independent boards of directors. RCDs implement projects on private and public lands and educate landowners about resource conservation. Each RCD can provide local information on project and programs to control agricultural NPS pollution. The California Association of Resource Conservation District’s Web site provides a link to each RCD. The California Association of Resource Conservation Districts is a voluntary association whose primary purpose is to provide a unified means for California RCDs to meet major conservation goals.

- **USDA NRCS Electronic Field Office Technical Guide** ([http://www.nrcs.usda.gov/technical/efotg/](http://www.nrcs.usda.gov/technical/efotg/)): Technical guides are the primary technical references for USDA NRCS. They contain technical information about the conservation of soil, water, air, and related plant and animal resources. Technical guides used in each field office are localized so that they apply specifically to the geographic area for which they are prepared. These documents are referred to as Field Office Technical Guides (FOTGs). The FOTG is maintained in each USDA NRCS field office as a compilation of technical knowledge, resource data references, and conservation practice standards. Click on California for a direct link to the California FOTG.

- **USDA NRCS, CORE4 Conservation Practices Training Guide** ([http://www.nrcs.usda.gov/technical/ECS/agronomy/core4.pdf](http://www.nrcs.usda.gov/technical/ECS/agronomy/core4.pdf)): The purpose of this workbook is to enhance the technical knowledge of USDA NRCS personnel and their colleagues in both the public and private sector and to assist them in helping landowners effectively use conservation tillage, nutrient management, pest management, and conservation buffers.

- **USEPA, National Management Measures to Control Nonpoint Source Pollution from Agriculture** ([http://www.epa.gov/owow/nps/agm/](http://www.epa.gov/owow/nps/agm/)): This is a technical guidance and reference document for use by state, local, and tribal managers in the implementation of NPS pollution management programs. It contains information on the best available, economically achievable means of reducing pollution of surface and ground water from agriculture.

- **USEPA, National Agriculture Compliance Assistance Center** ([http://www.epa.gov/agriculture/index.html](http://www.epa.gov/agriculture/index.html)): The National Agriculture Compliance Assistance Center (the Ag Center) provides information about environmental requirements that affect the agricultural community. The USEPA, with the support of USDA, created the Ag Center.

- **Livestock and Poultry Environmental Stewardship Curriculum** ([http://www.lpes.org/](http://www.lpes.org/)): This project delivers a national curriculum and supporting educational tools to U.S. livestock and poultry industry advisors, who help producers acquire certification and achieve environmentally sustainable production systems. Producers will also benefit directly from the information and assessment tools that the curriculum provides.
2.1.3 Management Measure 1A
Erosion and Sediment Control

Management Measure

Apply the erosion component of a conservation management system (CMS) as defined in the Field Office Technical Guide of the U.S. Department of Agriculture’s Natural Resources Conservation Service (USDA NRCS) to minimize the delivery of sediment from agricultural lands to surface waters, or design and install a combination of management and physical practices to settle the settleable solids and associated pollutants in runoff delivered from the contributing area for storms of up to a 25-year, 24-hour frequency.

2.1.3.1 Programs

- The Sonoma County Agricultural Commission, Agriculture Division, administers the Sonoma County Vineyard Erosion and Sediment Control Ordinance. Growers planting new vineyards or replanting existing vineyards are required to use recognized conservation practices, and management practices and provide for riparian setback to protect the environment and watersheds of the county (http://www.sonoma-county.org/agcomm/agcomm_division/aboutus.htm).
- The California Tahoe Conservancy has undertaken a comprehensive program to reduce the sources of soil erosion and the amount of sediment and algae-encouraging nutrients that reach Lake Tahoe (http://www.tahoecons.ca.gov/programs/soil/prg_soil.html).

2.1.3.2 Management Practices

The purpose of this management measure is to prevent and reduce the amount of soil entering surface water. California-approved USDA NRCS standards and practices should be used to prevent and reduce erosion on the field or to trap and settle sediment at the edge of the field. Strategies used to control rill and sheet erosion, streambank erosion, soil mass movement, and irrigation-induced erosion should be used as required in the erosion component of a conservation management system (CMS). Recommended practices include the following:

- Erosion can be reduced or prevented by leaving crop residues on the field, planting cover crops or other vegetative cover, and applying mulch to bare fields. In addition, fields can be graded to reduce slope length, steepness, or unsheltered distance (i.e., contour farming), and terraces and diversions can be used to reduce slope length. Finally, cross-wind strips can be installed and hedgerows, trees, and shrubs can be maintained along edges of fields or against prevailing winds to prevent wind erosion.
- Soil quality can be maintained through crop rotation, which involves planting crops in a recurring sequence on the same field, and by using conservation tillage to improve soil properties and improve water infiltration.
- Eroded sediment and associated pollutants can be trapped before leaving the site by installing filter strips, field borders, fiber mats, and buffers to filter and trap sediment. Grassed waterways can be installed to prevent gullies and to filter and trap sediment, and sediment ponds, basins, and traps can be used to treat sediment-laden runoff.
Techniques such as prescribed grazing, designated animal crossings over streams, and exclusion of animals from streambanks can prevent excessive erosion of fields and riparian areas from hoof traffic.

Irrigation management techniques can be used to control erosion caused by irrigation.

2.1.3.3 Information Resources

- **The Wine Institute** ([http://www.wineinstitute.org/communications/highlight/hom_1jan02.htm](http://www.wineinstitute.org/communications/highlight/hom_1jan02.htm)): The Wine Institute provides information on sustainable winegrowing practices. This Web site features cover cropping and highlights the experiences and expertise of Trinchero Family Estates, Cinnabar Vineyards, and Winery and Domaine Chandon.

- **University of California, Davis, Cooperative Extension, Sample Erosion Control Plan for the XYZ Ranch** ([http://agronomy.ucdavis.edu/calrng/sample_ECP.HTM](http://agronomy.ucdavis.edu/calrng/sample_ECP.HTM)): This Web site features an erosion control plan that was submitted for several acres in the Garcia River. The plan identifies areas of sediment delivery, identifies areas at risk of sediment delivery, and presents a schedule to control all sediment delivery associated with past and present land management activities.


- **CORE4, Crop Residue Management Facts** ([http://www.ctic.purdue.edu/Core4/CT/Definitions.html](http://www.ctic.purdue.edu/Core4/CT/Definitions.html)): This fact sheet provides information on crop residue management and conservation tillage.

- **CORE4, Ten Benefits of Conservation Tillage** ([http://www.ctic.purdue.edu/Core4/CT/CTSurvey/10Benefits.html](http://www.ctic.purdue.edu/Core4/CT/CTSurvey/10Benefits.html)): This fact sheets describes the 10 benefits of conservation tillage.

- **University of Illinois, College of Agriculture, Cooperative Extension Service, 60 Ways Farmers Can Protect Their Surface Water** ([http://www.thisland.uiuc.edu/60ways/60ways.html](http://www.thisland.uiuc.edu/60ways/60ways.html)): This Web site includes information on managing surface cover on agricultural lands and controlling water flow on steep slopes.


2.1.3.4 Case Studies

*Protecting Hillsides and Fish Habitat at Navarro Vineyards.* The steep slopes of Anderson Valley in Mendocino County have some of the thinnest soils and heaviest rainfalls in California, averaging 40 to 90 inches annually. Controlling soil erosion is important for local vintners, including the husband-wife team of Ted Bennett and Deborah Cahn of Navarro Vineyards in Philo. Bennett and Cahn control erosion to help keep pollutants carried with sediment out of the fish habitat in the Navarro River. They mapped the property to determine the main watershed areas and then developed management practices for the vineyards and roads—critical areas that are often conduits for runoff.
Each year the winery regrades the roads on a slant to direct the water flow to the inside slope. As the water runs down the inside channel, it falls into one of 60 stone drop boxes that catch the flow and divert it safely off the sides of the roads through underground culvert drains. Piles of rocks dissipate the impact of the water as it comes out of the culverts. The Navarro vineyard staff check the culverts after every big rain to clear any debris. The roads are also closed after a storm so that vehicles do not tear up the roads.

The Navarro vineyard staff also maintain the roads by planting a ground cover of hydro-seed, a special slurry of straw, water, and grass seed, applied on the banks or potential erosion sites before the rains. They protect eroded areas with biodegradable material such as straw matting and coconut husks. Perennial grasses are grown in the waterways so that runoff will not form erosion gullies. In the vineyards, the staff composts and irrigates grass cover crops on all rows to help hold the soil in place during winter. Later, alternating rows are mowed and tilled or, in very steep areas, just mowed. Navarro is vigilant in keeping rodent populations in check, because rodent tunnels speed soil erosion (http://www.wineinstitute.org/communications/highlight/hom_1oct02.htm).

**The California Integrated Waste Management Board (CIWMB).** The board has funded four erosion control and NPS pollution projects in California. Three of these projects involve commercial grape and citrus growers using mulch (http://www.ciwmb.ca.gov/Organics/GreenTeam/Target6/ProjMap.htm).

**The Central Coast Vineyard Team.** The Team reported that cover crops of clover, barley, and rye were planted to prevent the Robert Mondavi vineyards’ soils from eroding after the vines were first planted last year (http://www.vineyardteam.org/news/waterquality.htm).

**California NRCS Buffer Initiative.** A vineyard owner in Napa Valley established 50- to 100-foot setbacks to protect streams from the effects of erosion and chemical application. The size of his vineyards was reduced in some cases by 10 percent, resulting in less revenue, but capital costs for stabilizing the stream periodically with riprap were eliminated. Establishment of the buffer contributed positively to water quality by visibly reducing the turbidity of the stream (http://www.nrcs.usda.gov/feature/buffers/calif.html).

### 2.1.3.5 References


2.1.4 Management Measure 1B
Facility Wastewater and Runoff from Confined Animal Facilities That Are Not CAFOs

Management Measure

Limit the discharge from the confined animal facility that is not a CAFO by:

1. Containing both facility wastewater and the contaminated runoff from confined animal facilities at all times, up to and including storms exceeding a 25-year, 24-hour frequency event [storage facilities should be of adequate capacity to allow for proper wastewater utilization and should be constructed so they prevent seepage to ground water]; and

2. Managing stored runoff and accumulated solids from the facility through an appropriate waste utilization system that is consistent with Management Measure 1C.

2.1.4.1 Programs

- The California Dairy Quality Assurance (CDQA) Program was created to assist dairy producers with navigating and complying with the rules and regulations governing the industry. The CDQA program is a voluntary partnership between dairy producers, government agencies, and academia to address environmental stewardship, animal welfare, and food safety issues. The environmental stewardship module has three components: education, self-assessment, and third-party evaluation, terminating in certification, and focuses on compliance with federal, state, and local water quality regulations. A comprehensive checklist is used as the assessment tool in the certification process (http://www.cdqa.org/).

- The Equine Facilities Assistance Program. In July of 1997, the Council of Bay Area Resource Conservation Districts launched the program entitled “Non-Point Source Water Pollution Reduction through Improved Animal Waste and Resource Management at Equestrian Facilities in the San Francisco Bay Area,” to promote sound conservation practices at horse facilities. A manual and fact sheets can be found at the project’s Web site (http://www.baysavers.org/projects/equine/equinefacilities.html).

2.1.4.2 Management Practices

The purpose of this management measure is to limit the discharge of manure, litter, and process wastewater from a confined animal facility that is not a Concentrated Animal Feeding Operation (CAFO). Facilities that are defined as CAFOs under USEPA regulations (40 CFR §122.23) are considered point source dischargers and must secure coverage under an NPDES permit. Such facilities are subject to the terms and conditions of that permit.

All other confined animal facilities are considered nonpoint sources. These nonpoint sources, however, must still comply with animal waste discharge standards found at sections 22560 through 22565 of Title 27 of the California Code of Regulations (http://www.calregs.com) and with any applicable waste discharge requirements or waiver. The following practices are recommended for controlling and preventing NPS pollution from confined animal facilities. These practices may also be helpful in achieving compliance with statewide requirements:
Liquid manure storage structures should be designed to store facility wastewater and the contaminated runoff from confined animal facilities at all times, up to and including storms exceeding a 25-year, 24-hour frequency event, and should be consistent with nutrient management plans designed for the facility.

Dry manure should be stored in production buildings or storage facilities, or otherwise covered to prevent manure from coming into contact with rainwater and entering surface waters through runoff.

Each facility should have a nutrient management plan (USDA NRCS Standard 590) and land-apply manure and process wastewater in accordance with the plan.

Clean water should be diverted from contact with feedlots and holding pens, animals, and manure storage facilities through the use of berms, diversions, roofs, or enclosures.

Dead animals should be managed in a way that does not affect water quality.

Seepage of liquid wastes to ground and surface water should be prevented through the use of impermeable linings for liquid storage ponds and concrete pads for solid storage and animal traffic areas.

2.1.4.3 Information Resources

- **University of California, Davis, Animal Science Extension, Dairy Manure Management Series** ([http://animalscience.ucdavis.edu/extension/WasteManagement.htm](http://animalscience.ucdavis.edu/extension/WasteManagement.htm)): This Web site series provides information on dairy waste management.

- **Orange County, CA, Water Quality Guidelines for Horse and Livestock Activities** ([http://www.ocwatersheds.com/brochures/horses.pdf](http://www.ocwatersheds.com/brochures/horses.pdf)): This brochure has been prepared to inform residents in Orange County of the guidelines recommended for horse and livestock management in order to protect the water quality in storm drains, channels, creeks, bays, and the ocean.

- **USEPA Region 9, Animal Waste Management** ([http://www.epa.gov/region09/cross_pr/animalwaste/index.html](http://www.epa.gov/region09/cross_pr/animalwaste/index.html)): This Web site provides information on waste management programs for animal feeding operations in USEPA Region 9.

- **USEPA, National Agriculture Compliance Assistance Center** ([http://www.epa.gov/agriculture/anafobmp.htm](http://www.epa.gov/agriculture/anafobmp.htm)): This Web site provides information on operating procedures, schedules of activities, maintenance procedures, and other management practices that confined animal facilities can use to prevent or reduce pollution.

- **USDA NRCS, Nation Water and Climate Center, Animal Waste Management** ([http://www.wcc.nrcs.usda.gov/awm/](http://www.wcc.nrcs.usda.gov/awm/)): This Web site contains links to tools and information related to the development of animal waste management systems and comprehensive nutrient management plans (CNMPs) for confined animal facilities.


- **USDA NRCS, Agricultural Waste Management Field Handbook** ([http://www.fhw.nrcs.usda.gov/awmfh.html](http://www.fhw.nrcs.usda.gov/awmfh.html)). This handbook provides technical assistance for facilities designing agricultural waste management systems.

Web site has a series of informational materials on environmentally sound horse-keeping practices.

- **Livestock and Poultry Curriculum, Module C Manure Storage and Treatment and Module D Land Application and Nutrient Management** ([http://www.lpess.org/les_plans.html](http://www.lpess.org/les_plans.html)): The Livestock and Poultry Curriculum is a national curriculum and supporting educational tools developed for U.S. livestock and poultry industry advisors and producers to help them acquire certification and achieve environmentally sustainable production systems. Modules C and D provide presentations and material on manure storage, storage technology, treatment technologies, manure utilization plans, land application management practices, record keeping, and sampling.

- **University of Illinois, College of Agriculture, Cooperative Extension Service, 60 Ways Farmers Can Protect Their Surface Water** ([http://www.thisland.uiuc.edu/60ways/60ways.html](http://www.thisland.uiuc.edu/60ways/60ways.html)): This Web site provides information on managing livestock waste effectively.

### 2.1.4.4 Case Study

*The Dairy Biologically Integrated Farming Systems (BIFS) Project: Integrating Forage Production with Dairy Manure Management in the San Joaquin Valley.* In California's Central Valley, dairy manure has been identified as a source of nitrate that contributes to ground water pollution. The Dairy BIFS project encourages dairy farmers to manage manure as a valuable source of nutrients for forage crops used in the same dairy. This reduces environmental pollution while decreasing dairy production costs. Participating farmers have been able to drastically reduce, and in some cases, completely forgo, the application of synthetic nitrogen to their crops without affecting yield. Recent results indicate a substantial reduction in nitrogen, potassium, and phosphorus inputs without reductions in yield ([http://dairybifs.uckac.edu/](http://dairybifs.uckac.edu/)).

### 2.1.4.5 References


2.1.5 Management Measure 1C
Nutrient Management

Management Measure

Develop, implement, and periodically update a nutrient management plan to (1) apply nutrients at rates necessary to achieve realistic crop yields, (2) improve the timing of nutrient application, and (3) use agronomic crop production technology to increase nutrient use efficiency. When the source of the nutrients is other than commercial fertilizer, determine the nutrient value and the rate of availability of the nutrients. Determine and credit the nitrogen contribution of any legume crop. Soil and plant tissue testing should be used routinely. Nutrient management plans contain the following core components:

1. Farm and field maps showing acreage, crops, soils, and water bodies.

2. Realistic yield expectations for the crop(s) to be grown, based primarily on the producer’s yield history, State Land Grant University yield expectations for the soil series, or USDA NRCS Soils-5 information for the soil series.

3. A summary of the nutrient resources available to the producer, which at a minimum include (a) soil test results for pH, phosphorus, nitrogen, and potassium; (b) nutrient analysis of manure, sludge, mortality compost (birds, pigs, etc.), or effluent (if applicable); (c) nitrogen contribution to the soil from legumes grown in rotation (if applicable); and (d) other significant nutrient sources (e.g., irrigation water).

4. An evaluation of the field limitations based on environmental hazards or concerns such as (a) sinkholes, shallow soils over fractured bedrock, and soils with high leaching potential; (b) lands near surface water; (c) highly erodible soils; and (d) shallow aquifers.

5. Use of the limiting nutrient concept to establish a mix of nutrient sources and requirements for the crop based on realistic yield expectations.

6. Identification of timing and application methods for nutrients to: (a) provide nutrients at rates necessary to achieve realistic yields, (b) reduce losses to the environment, and (c) avoid applications as much as possible to frozen soil and during periods of leaching or runoff.

7. Provisions for the proper calibration and operation of nutrient application equipment.

8. Steps to ensure that when manure from confined animal facilities (excluding CAFOs) is to be used as a soil amendment or is disposed of on land, subsequent irrigation of the land does not leach excess nutrient to surface or ground waters.

2.1.5.1 Programs

- Pacific Northwest Collaborative Nutrient Management Education Program works to increase the ability of agricultural professionals to support landowners in sustainable nutrient management decisions that minimize negative impacts of nutrients on the environment and human health (http://wsare.usu.edu/projects/2002/EW00-011.pdf).

Last Updated July 30, 2004
University of California, Davis, Department of Animal Sciences offers assistance with planning and designing dairy waste management facilities and estimating the nutrient application rate of dairy manure (http://animalscience.ucdavis.edu/java/DairyWasteMgt/default.htm).

2.1.5.2 Management Practices
The purpose of this management measure is to reduce the nutrient loss from agricultural lands, which occurs through edge-of-field runoff or leaching from the root zone. The most effective way to manage nutrients is to develop a nutrient management plan (NMP) in accordance with USDA NRCS Standard 590. NMPs should be updated at least once every 5 years or once per crop rotation period. Records of nutrient use and sources should be maintained for easy reference. Components of an NMP include the following:

- Farm and field maps showing acreage, crops, soils, and water bodies.
- Realistic yield expectations for the crop(s) to be grown based primarily on the producer’s yield history, State Land Grant University yield expectations for the soil series, or USDA NRCS Soils-5 information for the soil series.
- A summary of the nutrient resources available to the producer, which at a minimum include (a) soil test results for pH, phosphorus, nitrogen, and potassium; (b) nutrient analysis of manure, sludge, mortality compost (birds, pigs, etc.), or effluent (if applicable); (c) nitrogen contribution to the soil from legumes grown in rotation (if applicable); and (d) other significant nutrient sources (e.g., irrigation water).
- An evaluation of the field limitations based on environmental hazards or concerns such as (a) sinkholes, shallow soils over fractured bedrock, and soils with high leaching potential; (b) lands near surface water; (c) highly erodible soils; and (d) shallow aquifers.
- Use of the limiting nutrient concept to establish a mix of nutrient sources and requirements for the crop based on realistic yield expectations.
- Identification of timing and application methods for nutrients to (a) provide nutrients at rates necessary to achieve realistic yields, (b) reduce losses to the environment, and (c) avoid applications as much as possible to frozen soil and during periods of leaching or runoff.
- Provisions for the proper calibration and operation of nutrient application equipment.
- Provisions to ensure that, when manure from confined animal facilities (excluding CAFOs) is to be used as a soil amendment or is disposed of on land, subsequent irrigation of the land does not leach excess nutrient to surface or ground waters.

2.1.5.3 Information Resources
- California Department of Food and Agriculture’s Fertilizer Research and Education Program (FREP) (http://www.cdfa.ca.gov/is/frep/index.htm): This program was created to advance the environmentally safe and agronomically sound use and handling of fertilizer materials. FREP facilitates and coordinates research and demonstration projects by providing funding and developing and disseminating information. It funds research to develop information on crops, irrigation methods, and nitrate in the soil as well as other environmental issues related to fertilizer use, such as heavy metals.
- University of California, Davis, Pomology Department, Nitrogen Fertilization Recommendation for Almond (http://fruitsandnuts.ucdavis.edu/almond/html/almond_n_model.html): This model calculates the
nitrogen requirement for almond production based upon the yield history, current conditions, and previous nitrogen applications. This model can be used to calculate both timing and rate of fertilizer application required to maintain optimum yield. Site-specific information is required for accurate projection of nitrogen requirement; hence this model should be applied to each distinct management unit, such as a block or field. The data used in this model were derived from exhaustive tree-nitrogen budget determinations.

- **CORE4, Crop Nutrient Management** ([http://www.ctic.purdue.edu/Core4/nutrient/nutrmgmt.html](http://www.ctic.purdue.edu/Core4/nutrient/nutrmgmt.html)): This Web site provides information, links, and resources on crop nutrient management planning.

- **California Certified Crop Advisors** ([http://www.cacca.org/](http://www.cacca.org/)): The California Certified Crop Advisors (CCA) can help producers grow economically and environmentally sound crops. The California CCA program is a voluntary certification program for individuals who provide advice to growers on crop management and inputs. Their Web site lists certified crop advisors for California. For more information contact the California CCA (Telephone: 916-928-1625).


- **Colorado Comprehensive Nutrient Management Plan Workbook** ([http://www.colostate.edu/Depts/SoilCrop/extension/Soils/cnmp/](http://www.colostate.edu/Depts/SoilCrop/extension/Soils/cnmp/)): This Web site is designed to take livestock producers through the process of developing a comprehensive nutrient management plan, step-by-step. Livestock producers of all kinds including cattle-feeders, dairies, cow-calf operations, horse owners, and poultry and pork producers can use the Comprehensive Nutrient Management Plan Workbook.

- **Livestock and Poultry Curriculum, Module A Introduction and Module D Land Application and Nutrient Management** ([http://www.lpes.org/les_plans.htm](http://www.lpes.org/les_plans.htm)): The Livestock and Poultry Curriculum is a national curriculum and supporting educational tools developed for U.S. livestock and poultry industry advisors and producers to help them acquire certification and achieve environmentally sustainable production systems. Modules A and D provide presentations and material on whole farm nutrient planning, manure utilization plans, land application management practices, phosphorus management, record keeping, and sampling.

- **National Agriculture Compliance Center, Crops** ([http://www.epa.gov/agriculture/crops.html](http://www.epa.gov/agriculture/crops.html)): This page provides information about environmental requirements specifically relating to the production of many types of agricultural crops, including food, feed, and fiber crops, and specialty crops, such as tobacco, herbs, spices, mushrooms, seed crops, and aquatic plants.

- **University of Illinois, College of Agriculture, Cooperative Extension Service, 60 Ways Farmers Can Protect Their Surface Water** ([http://www.thisland.uiuc.edu/60ways/60ways.html](http://www.thisland.uiuc.edu/60ways/60ways.html)): This Web site includes information on managing nutrients effectively.

- **California Dairy Quality Assurance (CDQA) Program** ([http://www.cdqa.org](http://www.cdqa.org)): This project assists dairy producers to comply with the regulations governing confined animal facilities by providing educational resources and funding in the areas of food safety, animal health and welfare, and environmental stewardship.

### 2.1.5.4 References

2.1.6 Management Measure 1D
Pesticide Management

Management Measure
To reduce contamination of surface water and ground water from pesticides.

1. Evaluate the pest problems, previous pest control measures, and cropping history.

2. Evaluate the soil and physical characteristics of the site including mixing, loading, and storage areas for potential leaching or runoff of pesticides. If leaching or runoff is found to occur, steps should be taken to prevent further contamination.

3. Use integrated pest management (IPM) strategies that (a) apply pesticides only when an economic benefit to the producer will be achieved (i.e., applications based on economic thresholds), and (b) apply pesticides efficiently and at a time when runoff losses are unlikely.

4. When pesticides applications are necessary and a choice of registered materials exists, consider the persistence, toxicity, runoff potential, and leaching potential of products.

5. Periodically calibrate pesticide spray equipment.

6. Use anti-blackflow devices on hoses used for filling tank mixtures.

2.1.6.1 Programs

- The California Pesticide Management Plan for Water Quality is a joint effort by the Department of Pesticide Regulation (DPR) and the SWRCB to protect water quality from the potential adverse effects of pesticides. It describes how DPR and the County Agricultural Commissioners work in cooperation with the SWRCB and the Regional Water Quality Control Boards (RWQCBs) to protect water quality from the use of pesticides (http://www.cdc.gov/nasd/docs/d000901-d001000/d000990/d000990.html#ii).

- The Department of Pesticide Regulation’s Surface Water Quality Program addresses both agricultural and nonagricultural sources of pesticide residues in surface waters. It has preventive and response components that reduce the presence of pesticides in surface waters. The preventive component includes local outreach to promote management practices that reduce pesticide runoff. Prevention also relies on DPR's registration process in which potential adverse effects on surface water quality, particularly those in high-risk situations, are evaluated. The response component includes mitigation options to meet water quality goals, recognizing the value of self-regulating efforts to reduce pesticides in surface water as well as the regulatory authorities of DPR, the SWRCB, and the RWQCBs (http://www.cdpr.ca.gov/docs/sw/).

- The Department of Pesticide Regulation’s Ground Water Quality Program addresses both agricultural and nonagricultural sources of pesticide residues in ground waters. The DPR is proposing to revise the Ground Water Quality Program by changing the current ground water regulations. For more information go to http://www.cdpr.ca.gov/docs/gwp/.
The Coalition for Urban/Rural Environmental Stewardship (CURES) has two programs to promote the environmental friendly use of pesticides. The Water Steward Orchard Program is designed to promote awareness of pesticide runoff from products used in dormant orchard sprays. The Water Steward Rice Program is a rice pesticide stewardship plan launched by CURES, the California Rice Commission, and a broad coalition of grower and industry interests. The purpose of this program is to raise awareness of rice pesticides and impacts on the drinking water quality of the Sacramento River (http://www.curesworks.org/).

- California Department of Pesticide Regulation, Pest Management Alliance (http://www.cdpr.ca.gov/docs/ipminov/ipmmenu.htm): This program provides support for agricultural, nonagricultural, and urban groups to develop and demonstrate pest management systems that reduce risks associated with pesticide use, including risks to surface and ground waters. The Web site has Alliance project evaluations, reports, and other technical information available for pest management systems in various commodities such as almonds, stone fruit, and strawberries.

### 2.1.6.2 Management Practices

The purpose of this management measure is to reduce or eliminate pesticide runoff into surface water. The most effective approach is to apply pesticides as prescribed on the label with respect to timing and rate of chemical application. The following practices should be considered to reduce the likelihood that pesticides will pollute surface and ground water.

- **Evaluate pest control needs:** Determine the extent of the pest problems, previous pest control measures, and cropping history. Consider using integrated pest management (IPM) to reduce the amount of chemicals needed to manage pest damage. See the University of California Statewide Integrated Pest Management Program (http://www.ipm.ucdavis.edu/). Pest management practices should be updated when crop rotation, pest problems, or type of pesticide used have changed.

- **Reduce the risk of accidental spills:** Know the physical and soil characteristics of the area and evaluate the site for runoff potential to surface water and leaching potential to ground water. Note the location and proximity of the mixing, loading, and storage areas relative to surface water. Use anti-backflow devices on hoses used for filling tank mixtures and on chemigation systems.

- **Maintain application equipment:** Calibrate application equipment once a season and inspect application equipment for wear and damage.

- **Follow the label:** Apply and use pesticides as prescribed on the label and at times when leaching and runoff are least likely (not just before a rainstorm).

- **Protect surface waters from spills and contaminated runoff:** Install perimeter controls such as vegetative buffers to help prevent pesticide runoff into streams.

### 2.1.6.3 Information Resources

- **University of California Statewide Integrated Pest Management Program** (http://www.ipm.ucdavis.edu): The UC IPM Program Web site contains information for practitioners on how to identify and manage pests, including educational resources, databases, publications, projects, and other resources.

- **University of California Statewide Integrated Pest Management Program, Dormant Spray Alternatives Calculator** (http://www.ipm.ucdavis.edu/WATER/OPCALC): This calculator estimates the costs of using organophosphate dormant sprays and selected alternative practices. When compared to conventional organophosphate dormant sprays, the alternatives listed in the
calculator offer favorable levels of pest control efficacy with comparable ranges of cost, while affording a reduced risk of aquatic toxicity.

- **The National Integrated Pest Management Network (NIPMN)** ([http://www.reeusda.gov/agsys/nipmn/index.htm](http://www.reeusda.gov/agsys/nipmn/index.htm)): NIPIMN is the result of a public-private partnership dedicated to making the latest and most accurate pest management information available on the World Wide Web. For projects and IPM techniques specific to the Western Region visit [http://www.colostate.edu/Depts/IPM/index.html](http://www.colostate.edu/Depts/IPM/index.html).


- **The Coalition for Urban/Rural Environmental Stewardship** ([http://www.curesworks.org/](http://www.curesworks.org/)): The Coalition for Urban/Rural Environmental Stewardship (CURES) was founded in 1997 to support educational efforts for agricultural and urban communities focusing on the proper and judicious use of pest control products.

- **CORE4, Weed and Pest Management** ([http://www.ctic.purdue.edu/Core4/ipm/IPM.html](http://www.ctic.purdue.edu/Core4/ipm/IPM.html)): This Web site provides information and resources related to weed and pest management.

- **University of Illinois, College of Agriculture, Cooperative Extension Service, 50 Ways Farms Can Protect Their Groundwater** ([http://www.thisland.uiuc.edu/50ways/50ways.html](http://www.thisland.uiuc.edu/50ways/50ways.html)): This Web site provides information on how to reduce contamination of ground water from fertilizers, herbicides, and insecticides; how to use integrated pest management; and how to improve chemical application.

- **University of Illinois, College of Agriculture, Cooperative Extension Service, 60 Ways Farmers Can Protect Their Surface Water** ([http://www.thisland.uiuc.edu/60ways/60ways.html](http://www.thisland.uiuc.edu/60ways/60ways.html)): This Web site includes information on reducing insecticide and pesticide use, selecting appropriate pesticides, and handling pesticides safely and efficiently.

- **Florida Department of Agriculture and Consumer Services and Florida Department of Environmental Protection, Best Management Practices for Agrichemical Handling and Farm Equipment Maintenance** ([http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/agbmp3p.pdf](http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/agbmp3p.pdf)).

### 2.1.6.4 Case Studies

**National Integrated Pest Management Network Success Story: Integrated Methods Keep Good Pears from Going Bad in Oregon.** Oregon IPM researchers have developed a protocol for maintaining high-quality pears in storage for many months. This methodology comprises a variety of environmentally friendly techniques, unlike traditional programs that rely on fungicides ([http://www.colostate.edu/Depts/IPM/index.html](http://www.colostate.edu/Depts/IPM/index.html)).

**Central Coast Vineyard Team Exploring Reduced Pesticide Use.** The Central Coast Vineyard Team (CCVT) is a community-based partnership of wine grape growers, wineries, University of California Cooperative Extension farm advisors, consultants, and the Department of Pesticide Regulation (DPR). Robert Mondavi Winery provided the leadership to create the team in 1995 to investigate ways to reduce pesticide use in the tri-county area. In 1996 the team received a grant from DPR to create California's first Positive Points System (PPS) for wine grapes. The PPS is being used to measure growers' environmental enhancement by evaluating their integrated farm management plans ([http://www.vineyardteam.org/about/index.htm](http://www.vineyardteam.org/about/index.htm)).
Almond Pest Management Alliance. The Almond Pest Management Alliance—with partners such as the Almond Hullers and Processors Association, the Community Alliance with Family Farmers, the University of California Statewide Integrated Pest Management Project, and University of California Cooperative Extension—is evaluating the possibility of reducing pesticide inputs in California almonds. Research began in 1998 when the California Department of Pesticide Regulation awarded its first grant to the Almond Pest Management Alliance. This effort was initiated because of two major concerns: The implementation of the Federal Food Quality Protection Act, with the possible loss of some traditional crop protection tools, and growing public concern over water quality standards in the San Joaquin River and Sacramento River watersheds, with possible links to pesticides used by almond growers.

The evaluation consists of three regional projects to encompass the variability of the almond-growing area of California. Each project compares conventional treatment areas with reduced risk treatment areas using practices appropriate for local conditions. The fourth year of the Almond Pest Management Alliance has also demonstrated that (a) extensive orchard monitoring is the key to the success of this approach, (b) reduced risk practices appear to be controlling the pests below economic damage levels, (c) other pests may begin to build populations after spray programs are altered, and (d) growers are interested in reduced risk practices and continue to be proactive. As the Almond Pest Management Alliance entered its fifth year in mid-2002, its goals included involving more pest control advisors (PCAs) and growers in monitoring during the crop season and through the dormant season; implementing smaller, more frequent, more regionally based field meetings regarding reduced risk practices; creating guidelines or protocols for reduced risk pest management in almonds based on what has been learned in the Pest Management Alliance project, and using a continuing Pest Management Alliance as an umbrella sponsorship entity to continue IPM and related agricultural stewardship research (http://www.cdpr.ca.gov/docs/empm/alliance/00-01/00-0210S.pdf).

Lodi-Woodbridge Winegrape Commission (LWWC) Sustainable Viticulture Program. There are three parts to LWWC’s Sustainable Viticulture Program: grower outreach, field implementation, and area-wide implementation. Grower outreach involves providing information to LWWC growers and PCAs about sustainable farming practices that are appropriate for use in their vineyards. This information is provided in a range of different ways briefly discussed below. The field implementation component involves working with a core group of 40 LWWC growers and about 15 PCAs in 60 different vineyards. Various sustainable farming practices are implemented in these vineyards so the growers and other LWWC members can see the effects of these practices. Area-wide implementation involves encouraging all LWWC members to become more active in implementing sustainable viticultural practices in their vineyards. The Lodi Winegrower's Workbook (http://www.lodiwine.com/winegrowersworkbook1.shtml) was written to help achieve area-wide implementation. More information about the Sustainable Viticulture Program can be found at http://www.lodiwine.com/viticultureprogram1.shtml.

2.1.6.5 References

2.1.7 Management Measure 1E
Grazing Management

Management Measure

Protect range, pasture, and other grazing lands by

1. Implementing one or more of the following to protect sensitive areas (such as streambanks, wetlands, estuaries, ponds, lake shores, and riparian zones): (a) exclude livestock, (b) provide stream crossings or hardened access to watering areas, (c) provide alternative drinking water locations away from surface waters, (d) locate salt and additional shade, if needed, away from sensitive areas, or (e) use improved grazing management (e.g., herding) to reduce the physical disturbance and reduce direct loading of animal waste and sediment caused by livestock; and

2. Achieving either of the following on all range, pasture, and other grazing lands not addressed under (1) above: (a) implement the range and pasture components of a CMS as defined in the USDA NRCS Field Office Technical Guide by applying the progressive planning approach of the USDA NRCS to reduce erosion, or (b) maintain range, pasture, and other grazing lands in accordance with activity plans established by the Bureau of Land Management of the U.S. Department of the Interior or the USDA Forest Service or the California Rangeland Water Quality Management Plan.

2.1.7.1 Programs

- The California Board of Forestry’s, California Rangeland Water Quality Management Plan is a voluntary plan developed by the California Cattlemen’s Association, in collaboration with University of California Cooperative Extension and USDA NRCS. The plan was officially approved in 1995 and includes rangeland water quality management strategies, policy and coordination mechanisms, as well as sample plans and sources of assistance. The California Board of Forestry is responsible for administering the plan [http://www.calcattlemen.org/CRWQMP.htm](http://www.calcattlemen.org/CRWQMP.htm).

- The Bureau of Land Management (BLM) has begun implementing the standards for rangeland health and guidelines for livestock grazing that apply to public lands administered by BLM in central and northern California and northwestern Nevada [http://www.ca.blm.gov/caso/sg_8-99.htm](http://www.ca.blm.gov/caso/sg_8-99.htm).

- The California Cattlemen’s Association’s Rangeland and Water Quality Web site provides access to the California Rangeland Water Quality Management Plan, which addresses both governmental policy and management strategies. The Grazing for Change booklet features nine California rancher’s range and watershed management success stories. The ongoing Riparian Grazing Project serves as another useful tool for range managers [http://www.calcattlemen.org/rwq.htm](http://www.calcattlemen.org/rwq.htm).

- The California Grazing Academy is a unique and exciting program emphasizing practical application of controlled grazing principles to improve the environment and increase ranch profit. This challenging course consists of a minimum of lecture and a maximum of hands-on experience and learning [http://ceplacer.ucdavis.edu/Livestock/California_Grazing_Academy_-_Low-Stress_Livestock_Handling_School.htm](http://ceplacer.ucdavis.edu/Livestock/California_Grazing_Academy_-_Low-Stress_Livestock_Handling_School.htm).
The California Department of Pesticide Regulation, Pest Management Alliance. DPR’s Pest Management Alliance program provides funding support, when funds become available, to encourage increased implementation of biologically intensive, reduced-risk pest management. This program is designed to create a collaborative, interdisciplinary team that uses a systems approach—the assumption is that team members have already solved pest problems and other specialized components through applied research. The Alliance is part of a problem-solving continuum, taking the data collected from research and preparing for the next stage—education through demonstration, and ultimately implementation. An overview of the program is available at http://www.cdpr.ca.gov/docs/empm/alliance/overview.htm; project summaries since 1998 are available at http://www.cdpr.ca.gov/docs/empm/alliance/allisums.htm.

2.1.7.2 Management Practices
The purpose of this management measure is to protect sensitive areas in range, pasture, and other grazing lands. California-approved USDA NRCS standards required for a conservation management systems should be applied to the entire grazing area. These components include erosion control, adequate pasture stand density, and rangeland condition. Recommended practices include the following:

- Carefully plan the use of grazing areas by developing a ranch plan with the goal of improving or maintaining water quality. Use prescribed grazing techniques to manage the intensity, frequency, and duration of grazing.
- Prevent erosion from wind or water by maintaining enough vegetative cover.
- Keep animals out of surface waters: exclude animals, people, or vehicles to protect and maintain plant and water quality and prevent or minimize direct loading of animal waste and sediment into surface waters. Install alternative drinking sources to keep animals away from sensitive waters and install hardened access points so animals have access to drinking water sources. Use fences, hedgerows, moats, and other practices to keep animals away from sensitive areas and place salt and additional shade away from sensitive areas.
- Provide stream crossings to minimize impacts on stream habitat and water quality.
- Use structural range improvements, like access roads, grade stabilizers, sediment ponds, stalk trails or walkways, troughs and tanks, pipelines, and streambank protection.
- Use practices such as prescribed burning, range seeding, brush management, stream corridor improvement, wetland and upland wildlife management to manage vegetation, prevent erosion, and protect wildlife habitat.

2.1.7.3 Information Resources
- USDA Forest Service, Grazing Management Assessment (http://www.caltrout.org/comm/otherpubs/GMA2001.pdf): The California Native Plant Society and California Trout have conducted research on California’s USDA Forest Service Grazing Management Program. This document includes a summary of some of the research projects.
- Grazing for Change, Range and Watershed Management Success Stories in California. For information about ordering a copy of this booklet, contact the California Cattlemen’s Association (Telephone: 916-444-0845; E-mail: staff@calcattlemen.org).
- University of California, Davis, California Rangelands Research Information Center (http://agronomy.ucdavis.edu/calrng/range1.htm): The purpose of this Web site is to develop
research and extension education initiatives and to foster collaboration between California rangeland researchers and educators.

- **University of California, Davis, Cooperative Extension, Controlled Grazing** ([http://www.foothill.net/~ringram/gzoption.htm](http://www.foothill.net/~ringram/gzoption.htm)): This Web site provides information on controlled grazing, which is a flexible management method that balances plant and animal requirements.

- **USDA NRCS, Grazing Land Conservation Initiative** ([http://www.nrcs.usda.gov/programs/glci/](http://www.nrcs.usda.gov/programs/glci/)): The Grazing Land Conservation Initiative (GLCI) is a nationwide collaborative process of individuals and organizations working to maintain and improve the management, productivity, and health of the nation’s privately owned grazing land. This process has formed coalitions that represent the grassroots concerns that impact private grazing land. The coalitions actively seek sources of funding to increase technical assistance and pursue public awareness activities that maintain or enhance grazing land resources.


- **Montana Department of Natural Resources and Conservation, Best Management Practices for Grazing** ([http://www.homepage.montana.edu/~harries/](http://www.homepage.montana.edu/~harries/)): This Web site presents grazing management practices for a water quality demonstration project.

- **National Agriculture Compliance Center, Pasture, Grazing, and Rangeland Operations** ([http://www.epa.gov/agriculture/anprgidx.htm](http://www.epa.gov/agriculture/anprgidx.htm)): This Web site provides information about environmental requirements specifically relating to livestock production in pastures and rangeland, as well as other grazing operations.

### 2.1.7.4 Case Study

**The Sustainable Ranching Research and Education Project.** The project is a long-term effort to improve the economic, environmental, and social sustainability of ranching ([http://ceplacer.ucdavis.edu/livestock/publications/sustranchovervw.pdf](http://ceplacer.ucdavis.edu/livestock/publications/sustranchovervw.pdf)).

**The Morro Bay Watershed Project.** Morro Bay, one of the few intact natural estuaries along California’s coast, is being impaired primarily by sediment. Brushland, rangeland, and streambank erosion contribute the largest portion of sediment deposited in the bay. The Morro Bay Watershed project is evaluating the effectiveness of sediment-reducing management practices, such as the creation of smaller pastures, installation of cattle watering systems, stabilization and revegetation of streambanks, and installation of water bars and culverts on farm roads. At one of the watershed study sites, a 49 percent reduction in turbidity was documented. A suite of management practices, including improved grazing management, riparian fencing, and revegetation, was responsible for the reduction in turbidity. These practices have also proved to be effective in reducing bacteria levels in adjacent streams in the watershed ([http://www.bae.ncsu.edu/programs/extension/wqg/section319/page1.htm](http://www.bae.ncsu.edu/programs/extension/wqg/section319/page1.htm)).
2.1.7.5 References


### 2.1.8 Management Measure 1F
#### Irrigation Water Management

**Management Measure**

To reduce NPS pollution of surface and ground waters caused by irrigation.

1. Operate the irrigation system so that the timing and amount of irrigation water applied match crop water needs. This requires, as a minimum, (a) the accurate measurement of soil-water depletion volume and the volume of irrigation water applied, and (b) uniform application of water.

2. When chemigation is used, include backflow preventers for wells, minimize the harmful amounts of chemigation waters that discharge from the edge of the field, and control deep percolation. In cases where chemigation is performed with furrow irrigation systems, a tailwater management system may be needed.

#### 2.1.8.1 Programs

- The California Department of Water Resources’ California Irrigation Management Information System (CIMIS) helps agricultural growers and turf managers who administer parks, golf courses, and other landscapes to develop water budgets for determining when to irrigate and how much water to apply (http://www.cimis.water.ca.gov/).

- The Department of Water Resources’ Agriculture Water Management Planning Program provides technical, financial, and administrative assistance to the Agricultural Water Management Council and to the water districts throughout the State to develop water management plans and to help implement cost-effective, efficient water management practices (http://www.owue.water.ca.gov/agmanage/index.cfm).

- AgLine Online, the Kings River Conservation District’s AgLine information system, provides crop water use information for the Kings River service area. Information provided for each crop includes crop water use for the past 7 days, predicted water use for the next 7 days, and total crop water use for the season to date. The numbers are updated every Friday and can be used to assist growers in irrigation management decisions. AgLine includes crop water use data for 31 cropping cases (http://krcd.org/).

- Westland Water District’s Water Conservation Cost-Share Programs continues to offer the Expanded Irrigation System Improvement Program (EISIP) to district water users and landowners. This program offers low interest rates to water users for the lease-purchase of irrigation system equipment funded by State Revolving Fund loans. The EISIP offers the opportunity to lease portable aluminum irrigation equipment and other improved irrigation systems, including microirrigation, linear move and center pivots, and tailwater reuse systems. The Agricultural Pumping Efficiency Program is available for all agricultural electric and natural gas utility accounts that are used for pumping water and paying the Public Goods Charge (customers of Pacific Gas and Electric Company, Southern California Edison Company, Southern California Gas Company, or San Diego Gas and Electric Company) (http://www.westlandswater.org/wtrcon/costshare.htm).
2.1.8.2 Management Practices

The purpose of this management measure is to reduce NPS pollution of surface and ground waters caused by irrigation. Irrigation water should be applied in a manner that ensures efficient use and distribution of the water and minimizes runoff and soil erosion. Recommended practices include the following:

- Determining and controlling the rate, amount, and timing of irrigation water in a planned and efficient manner. This entails knowing the daily water use of the crop, the water-holding capacity of the soil, and the lower limit of soil moisture for each crop and soil. It is also important to measure the amount of water applied to the field.

- Controlling the manner and application of water to minimize water runoff and soil erosion. USDA NRCS-recommended irrigation systems include microirrigation, sprinklers, surface and subsurface systems, and tailwater recovery systems.

- Designing irrigation water transport systems to eliminate as much water loss as possible.

- Lining irrigation channels to prevent seepage to ground water.

- Using a pipeline and apparatus to convey water to the irrigation system.

- Using a structure that controls the rate and timing of water conveyed to the irrigation system.

- Installing storage reservoirs to keep water for irrigation.

- Managing the drainage water from the irrigation system to control deep percolation, to move tailwater to the reuse system, and to control erosion and adverse impacts on surface and ground waters.

- Using filter strips to capture sediment and pollutants running off fields.

- Use grassed waterways to capture and trap sediment entering receiving waters.

- When irrigation water is conveyed down slopes that increase the velocity, causing erosion, install erosion controls, such as drops, chutes, buried pipelines, or erosion-resistant ditch linings.

- When using a chemigation system, install backflow preventers on wells to minimize the harmful amounts of chemigation waters that discharge from the edge of the field and to control deep percolation. In cases where chemigation is performed with furrow irrigation systems, a tailwater management system may be needed.

2.1.8.3 Information Resources

- Water Conservation Field Services Program, Demonstration of Innovative Technologies (http://www.usbr.gov/uc/progact/waterconsv/wtr_demon.html): Area programs are supporting local demonstration of projects such as improved water measurement, use of automation and telemetry control, approaches to minimizing canal and ditch seepage, and on-farm irrigation management methods. Activities include (1) assist with research, evaluation, and demonstration; (2) sponsoring conservation demonstration projects and activities; and (3) coordinating financial assistance for joint projects and partnerships with other agencies.

- The U.S. Bureau of Reclamation’s National Irrigation Water Quality Program (NIWQP) (http://www.usbr.gov/niwqp/): The NIWQP is an intra-departmental program that evaluates Department of the Interior irrigation projects, considers drainwater contamination and related impacts on endangered species and migratory birds, assesses legal responsibilities associated with environmental laws, and develops and implements alternatives for remediation.
2.1.8.4 Case Study

Water Use Efficiency Pilot Program 2001. The Yolo County Resource Conservation District undertook a 1-year pilot program funded by the CALFED Water Use Efficiency Program from December 2000 through December 2001. The District was selected for this pilot program because of its history as an innovator in on-farm water quality improvement techniques, especially those employing native perennial grasses, wetland plants, shrubs, and trees.

The District’s intent in taking on the pilot program was to initiate a more rigorous analysis of the assumed water quality benefits of practices it has long promoted: especially those of tailwater ponds, sediment traps and winter cover cropping. The actual water quality improvements associated with those conservation techniques had never been rigorously quantified. In light of the changing regulatory climate regarding farm runoff water quality, the information gathered may prove particularly useful for (a) informing regulators of acceptable and measurable water conservation techniques that can be used to meet their goals, and (b) informing farmers and water managers of proven tools that they can employ in their desire to best manage the water under their control.
The District works closely with local farmers and agricultural industry and is familiar with the stresses and realities of agricultural operations and the families who run them. The District is committed to exploring and promoting means of voluntary compliance without direct regulation to enable farmers to continue their business while properly managing public resources such as air, water, and wildlife.

Under this pilot program, tailwater ponds and sediment traps clearly served their function as devices that entrain sediment, especially when properly designed and maintained. Most of the traps and ponds studied provided some nutrient capture during the initial irrigations as well, although that aspect of their function requires further study.

The winter cover crop study also demonstrated both runoff flow attenuation and sediment reduction. Further study of the degree of success relative to planting date (likely the earlier, the better) and cover crop growth stage would help to gauge the most effective application of this technique.

Water use efficiency is compelling for farmers at the very least because of a potential decrease in pumping costs.

Although the District considers the information gathered through the pilot program to be useful to CALFED in its aim to promote locally led, on-farm water use efficiency programs, the pilot program has also provided an excellent opportunity for the District to refine its on-farm monitoring program and understanding of potential collaboration to promote water use efficiency in Yolo County.

Yolo County Resource Conservation District, Water Quality and Irrigation Ecosystem Management Project. The overall objective of this grant-funded program was to address both natural resources and stakeholders within the practical realities of farming, water delivery, and county road safety and maintenance. Funded by the SWRCB, with support from RWQCB 5, this project offered an integrated management approach that combined volunteer landowners and agency participation in a working partnership involving innovative practices. Applying these coordinated practices, the Yolo County Resource Conservation District (RCD) worked to improve water quality and biodiversity by targeting and installing tailwater retention basins as well as canal, roadside, and riparian vegetation systems.

Working in the Willow Slough watershed, the Yolo County RDC found that water problems are interrelated and circular. Contaminated with pesticides, sediment, and nutrients, agricultural tailwater runs freely through a degraded biological system where canals, creeks, and roadsides double as agricultural drains. The task was to find and demonstrate farm-friendly, cost-effective, and practical solutions.

This program implemented a set of structural and vegetative solutions in 1995-97, including five vegetated tailwater retention basins, 1 mile of vegetated canal bank, 1 mile of vegetated roadside, and one-quarter mile of riparian revegetation on a local slough. To extend these projects beyond the grant period, RCD staff provided training to local irrigation district canal tenders, farmers, and county road crews to install and maintain these restored areas in the future. (http://www.yolorcd.org/programs/irrigation_ecosystem/irrigatesys.shtml)

2.1.8.5 References

2.1.9 Management Measure 1G
Education and Outreach

Management Measure

Implement educational programs to provide greater understanding of watersheds, and to raise awareness and increase the use of applicable agricultural management measures and practices where needed to control and prevent adverse impacts on surface and ground waters. Public education, outreach, and training programs should involve user groups and the community.

2.1.9.1 Programs

- The California Grazing Academy is a unique and exciting program emphasizing practical application of controlled grazing principles to improve the environment and increase ranch profit. This challenging course consists of a minimum of lecture and a maximum of hands-on experience and learning (http://ceplacer.ucdavis.edu/Livestock/California_Grazing_Academy_-_Low-Stress_Livestock_Handling_School.htm).

- The Pacific Northwest Collaborative Nutrient Management Education Program has as its goal to increase the ability of agricultural professionals to support landowners in sustainable nutrient management decisions that minimize negative impacts of nutrients on the environment and human health (http://wsare.usu.edu/projects/2002/EW00-011.pdf).

- The Code of Sustainable Wine Growing Practices project organizes information workshops and distributes workbooks to all workshop attendees at no charge. The Wine Institute and the California Association of Winegrape Growers are working with California regional wine associations, vintners, and growers to organize and carry out workshops in each winegrowing region in the State. Regional associations or individual vintner and grower companies or both can host these workshops (http://www.wineinstitute.org/communications/SustainablePractices/workshops.htm).

- The University of California Sustainable Agriculture Research and Education Program is a statewide program administered by the university’s Agriculture and Natural Resources Department. It has three mandates: administer competitive grants for research on sustainable agriculture practices and systems, develop and distribute information through publications and on-farm demonstrations, and support long-term research in sustainable farming systems on University of California farmlands (http://www.sarep.ucdavis.edu/grants).

- Yolo County Total Resource Management/Model Farm Program (http://www.yolorcd.org/programs/trm_model_farms/modelfarm.shtml): Through a challenge grant from the U.S. Bureau of Reclamation, the Yolo County Resource Conservation District along with four other conservation districts and the California Association of Resource Conservation Districts worked with regional experts and six local growers to determine what form and impact Total Resource Management can have on Yolo County farms. The District selected its cooperators to represent a diversity of cropping systems and geographical locations within the county, including foothill rangelands, an organic walnut orchard, and high-production field and row crops. In October 2000 the District completed the 6-year project.
2.1.9.2 Management Practices

The purpose of this management measure is to implement educational programs to provide greater understanding of watersheds, and to raise awareness and increase the use of applicable agricultural standards and practices to control and prevent adverse impacts on surface and ground waters. Educational materials on agricultural NPS pollution and pollution prevention programs should be developed for the following:

- Activities that cause erosion and sediment loss and the practices that control erosion and sediment on agricultural lands.
- Activities that cause animal waste discharges from storage structures at confined animal facilities and appropriate application of nutrients to cropland.
- Activities that cause excess nutrient runoff into surface water or nutrient leaching into ground water and the measures that can control and prevent runoff.
- Prevention of pesticide runoff into surface water and pesticide leaching into ground water.
- Grazing activities that cause physical disturbance in sensitive areas and the discharge of sediment, animal waste, nutrients, and chemicals to surface and ground waters.
- Irrigation activities that cause NPS pollution of surface waters.

Public education and outreach programs should be developed at the appropriate level for the stakeholder group or audience it is designed to reach, using the following methods to educate and disseminate information to the specified audience:

- Use training programs to teach proper application of agriculture management practices.
- Establish bulletin boards for environmental messages and idea sharing.
- Hand out fact sheets, flyers, and pamphlets on controlling agricultural NPS pollution.
- Develop a handbook for local or regional producers and growers with recommended practices and standards to meet the requirements of the management measures.
- Organize meetings with local stakeholders.
- Develop an “Ag Center” or “one-stop shop” for farmers, growers, and producers to obtain information on NPS pollution prevention techniques, technologies, information resources, and idea exchange.
- Make available a directory of farm advisors, crop advisors, and nutrient management planners for producers and growers to contact for technical advice.
- Work with the local extension service offices and USDA NRCS offices to establish certification and continuing education programs in comprehensive nutrient management planning, grazing, irrigation, and pesticide management.

2.1.9.3 Information Resources

- California Department of Pesticide Regulation, Pest Management Alliance ([http://www.cdpr.ca.gov/docs/empm/alliance/pmagrnts.htm](http://www.cdpr.ca.gov/docs/empm/alliance/pmagrnts.htm)): California DPR’s Pest Management Alliance program Web site provides links to past and ongoing projects that were completed under
the Pest Management Alliance Program. The program provides funding support to encourage increased implementation of biologically intensive, reduced-risk pest management, and several successful projects are under way that can serve as examples for future pest management projects and innovations.

- **The University of California Sustainable Agriculture Research and Education Program** ([http://www.sarep.ucdavis.edu/](http://www.sarep.ucdavis.edu/)): The Sustainable Agriculture Research and Education Program is a statewide program administered by the university’s Agriculture and Natural Resources Department. Its Web site contains newsletters, publications, news releases and other media, educational programs, and funding opportunities related to such topics as crop and livestock production, biologically integrated farming systems (BIFS), organic farming, and local food systems.

- **The University of California Cooperative Extension Service** ([http://ucanr.org/CES.CEA.shtml](http://ucanr.org/CES.CEA.shtml)): The UC Cooperative Extension Service Web site offers information about food and nutrition, farming, pest control, natural resources, animal agriculture, gardening, and many other topics. Its publications page contains a variety of practical, research-based educational media such as publications, videos, slide presentations, interactive distance learning, audio recordings, and electronic multimedia. *California Agriculture*, the UC Agriculture and Natural Resources quarterly magazine, can also be accessed here.

- **The Coalition for Urban/Rural Environmental Stewardship (CURES)** ([http://www.curesworks.org/](http://www.curesworks.org/)): The Coalition for Urban/Rural Environmental Stewardship was founded in 1997 to support educational efforts for agricultural and urban communities focusing on the proper and judicious use of pest control products. The publications available from the CURES Web site include information on application stewardship, farm worker safety, ground application timing, and water quality protection.

- **Missouri Department of Natural Resources, Environmental Assistance Office (EAO)** ([http://www.dnr.state.mo.us/oac/ag.htm](http://www.dnr.state.mo.us/oac/ag.htm)): The Agricultural Assistance Unit within EAO assists farmers and agriculture-related businesses with their environmental needs. Much of that assistance includes guidance for environmental permits, natural resource stewardship, third-party site environmental assessments, and referrals as appropriate.

- **Louisiana State University, Ag Center** ([http://www.lsuagcenter.com/subjects/masterfarmer/](http://www.lsuagcenter.com/subjects/masterfarmer/)): The Master Farmer Program is an effort to demonstrate that agricultural producers can voluntarily reduce the impact that agricultural production has on Louisiana’s environment. The Master Farmer Program has three components: environmental stewardship, agricultural production, and farm management/marketing.

### 2.1.9.4 Case Study

*Monterey Bay National Marine Sanctuary*: The Agriculture and Rural Lands Action Plan was developed in 1999 to address agricultural water quality issues related to the sanctuary such as erosion control, nutrient runoff, and persistent pesticides. The plan had several components, including an agriculture industry network, technical information and outreach, education and public relations, regulatory coordination and streamlining, funding mechanisms and incentives, and public lands and rural roads. The technical information and outreach and the education and public relations sections of the plan are as follows:

Technical Information and Outreach: Although extensive technical information exists on agricultural techniques and tools to improve water quality, this information is not always readily available or easily usable for growers and ranchers who have many other facets of their business to attend to. The general...
intent of the strategies in this section of the plan is to make this information more accessible and useful through increased support for existing technical outreach services, development of networks, cross-training of outreach staff, packaging of easily understood information, and conducting onsite follow-up with workshop participants. Recent accomplishments and activities:

- The California NRCS has hired new technical staff for the sanctuary watershed region, including an agronomist, a water quality specialist and a rural roads engineer. Their work includes conducting technical workshops and providing technical assistance for site-specific concerns.
- Partners have begun a compilation of existing technical outreach materials to identify information gaps.
- University of California Cooperative Extension is researching the costs of common conservation measures in order to demonstrate the costs and benefits involved for landowners.
- Partners are working on the development and promotion of self-monitoring tools so that landowners can track changes over time.

Education and Public Relations: There is a need for improved education of the public about agricultural conservation issues, and of public and agricultural groups about watershed issues as a whole. The intent of the strategies in this section of the plan is to enhance public, grower, government agency, and media knowledge about watershed issues, and develop a better recognition and expansion of conservation practices that the agricultural community employs. Accurate, readily understandable information shared among these interest groups should serve as a basis for productive partnerships.

The following are recent accomplishments and activities:

- Regular media columns highlighting watershed issues and agricultural conservation efforts are being developed for local and regional newspapers and journals.
- A marketing firm has been hired to encourage farmer participation and public support for implementation of the plan.
- A Web site is being developed for use by multi-agency field staff, growers, and the public.

(http://www.mbnms.nos.noaa.gov/resourcepro/ag.html)
2.2 Forestry

2.2.1 Introduction

The California State Water Resources Control Board (SWRCB), California Coastal Commission (CCC), and other State agencies have identified 12 management measures to address various phases of forestry operations relevant to controlling nonpoint sources of pollution that affect State waters. The forestry management measures are for the most part a system of practices used and recommended by the Board of Forestry and Department of Forestry and Fire Protection in rules or guidance. Associated with each management measure are management practices that are designed to reduce the quantities of pollutants entering receiving waters. Forestry management practices are harvest and engineering techniques that help reduce nonpoint source (NPS pollution). Those who own and harvest the land are responsible for implementation of the management measures and management practices to minimize water quality impairment. Management practices that protect water quality are required by the California Forest Practice Rules. Many rules are specific to the regions or counties where forest management occurs. A registered professional forester can be of great assistance in navigating local regulations and developing a timber harvest plan. A fact sheet has been prepared for each management measure to inform readers of the programs, resources, and case studies specific to California and the management measure.

Silviculture contributes approximately 3 to 9 percent of NPS pollution to the nation's waters. This figure can be higher in some watersheds where silviculture is a major economic activity. Without adequate controls, forestry operations may degrade the characteristics of waters that receive drainage from forestlands. For example, sediment concentrations can increase because of accelerated erosion, water temperatures can increase because of removal of overstory riparian shade, dissolved oxygen can be depleted because of the accumulation of slash and other organic debris, and concentrations of organic and inorganic chemicals can increase because of harvesting and fertilizers and pesticides.

The NPS pollutant of greatest concern with respect to forestry activities is sediment. The potential for sediment delivery to streams from almost all timber-harvesting activities and from forest roads regardless of their level of use or age is a long-term concern. Other pollutants of significance, including nutrients, toxic chemicals and metals, organic matter, pathogens, herbicides, and pesticides, are also of concern; problems associated with these other pollutants and increases in temperature generally do not extend beyond 2 years from the time of harvest or are associated with a specific activity, such as an herbicide application. Nevertheless, all of these pollutants have the potential to affect water quality and aquatic habitat. Minimizing their delivery to surface water and ground water deserves serious consideration before and during forestry activities. Forest harvesting can also affect the hydrology of a watershed, and hydrologic alterations within a watershed have the potential to degrade water quality and adversely affect wetlands.

The California Management Measures for Polluted Runoff defines the 12 forestry management measures as follows:

Forestry Category Links:
- Preharvest Planning
- Streamside Management Areas
- Road Construction/Reconstruction
- Road Management
- Timber Harvesting
- Site Preparation and Forest Regeneration
- Fire Management
- Revegetation of Disturbed Areas
- Forest Chemical Management
- Wetlands Forest Management
- Postharvest Evaluation
- Education/Outreach
2A. Preharvest Planning. Pursuant to Management Measure 2A, silvicultural activities should be planned to reduce potential delivery of pollutants to surface waters. Components of Management Measure 2A address aspects of forestry operations, including the timing, location, and design of harvesting and road construction; site preparation; identification of sensitive or high-erosion risk areas; and the potential for cumulative water quality impacts.

2B. Streamside Management Areas (SMAs). SMAs protect against soil disturbance and reduce sediment and nutrient delivery to waters from upland activities. Management Measure 2B is intended to safeguard vegetated buffer areas along surface waters to protect the water quality of adjacent streams.

2C. Road Construction/Reconstruction. Pursuant to Management Measure 2C, road construction/reconstruction should be conducted so as to reduce sediment generation and delivery. This can be accomplished by, among other means, following preharvest plan layouts and designs for road systems, incorporating adequate drainage structures, properly installing stream crossings, avoiding road construction in SMAs, removing debris from streams, and stabilizing areas of disturbed soil such as road fills.

2D. Road Management. Management Measure 2D describes how to manage roads to prevent sedimentation, minimize erosion, maintain stability, and reduce the risk that drainage structures and stream crossings will fail or become less effective. Components of this measure include inspections and maintenance actions to prevent erosion of road surfaces and to ensure the effectiveness of stream-crossing structures. They also address appropriate methods for closing roads that are no longer in use.

2E. Timber Harvesting. Management Measure 2E addresses skid trail location and drainage, management of debris and petroleum, and proper harvesting in SMAs. Timber harvesting practices that protect water quality and soil productivity also have economic benefits by reducing the length of roads and skid trails, reducing equipment and road maintenance costs, and providing better road protection.

2F. Site Preparation and Forest Regeneration. Impacts of mechanical site preparation and regeneration operations—particularly in areas that have steep slopes or highly erodible soils, or where the site is located in close proximity to a water body—can be reduced by confining runoff onsite. Management Measure 2F addresses keeping slash material out of drainageways, operating machinery on contours, timing of activities, and protecting ground cover in ephemeral drainage areas and SMAs. Careful regeneration of harvested forestlands is important in protecting water quality from disturbed soils.

2G. Fire Management. Prescribed fire practices for site preparation and methods to suppress wildfires should, as feasible, be conducted in a manner that limits loss of soil organic matter and litter and that reduces the potential for runoff and erosion. Prescribed fires that remove forest litter down to mineral soil on steep slopes or adjacent to streams are most likely to affect water quality.

2H. Revegetation of Disturbed Areas. Management Measure 2H addresses the rapid revegetation of areas disturbed during timber harvesting and road construction—particularly areas within harvest units or road systems where mineral soil is exposed or agitated (e.g., road cuts, fill slopes, landing surfaces, cable corridors, or skid trails) with special priority for SMAs and steep slopes near drainageways.

2I. Forest Chemical Management. Application of pesticides, fertilizers, and other chemicals used in forest management should not lead to surface water contamination. Pesticides must be properly mixed, transported, loaded, and applied, and their containers disposed of properly.

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Fertilizers must also be properly handled and applied since they also may be toxic depending on concentration and exposure. Components of Management Measure 2I include applications by skilled workers according to label instructions, careful prescription of the type and amount of chemical to be applied, use of buffer areas for surface waters to prevent direct application or deposition, and spill contingency planning.

- **2J. Wetlands Forest Management.** Forested wetlands provide many beneficial water quality functions and provide habitat for aquatic life. Activities in wetland forests should be conducted to protect the aquatic functions of forested wetlands.

- **2K. Postharvest Evaluation.** The goals of Management Measure 2K are to incorporate postharvest monitoring, including (a) implementation monitoring to determine whether the operation was conducted according to specifications, and (b) effectiveness monitoring after at least one winter period to determine whether the specified operation prevented or minimized discharges.

- **2L. Education/Outreach.** The goals of Management Measure 2L are to implement pollution prevention and education programs to reduce NPS pollutants generated by applicable silvicultural activities.

### 2.2.2 General Resources

There are several federal and State agencies and programs that can provide general information to promote sustainable forestry practices and prevent NPS pollution from entering receiving waters. The agencies and programs listed below can provide assistance and information for all 12 management measures. Resources specific to each of the forestry management measures can be found on the corresponding fact sheet.

- **Contact a Forest Advisor** to help with understanding local regulations and developing a timber management plan (http://www.fire.ca.gov/ResourceManagement/PDF/ForestAdvisorList.pdf).

- **California Forest Stewardship Program** (http://ceres.ca.gov/foreststeward/index.htm): This program is designed to encourage good stewardship of private forestland. The program provides technical and financial assistance to influence positive changes to forestland management, assists communities in solving common watershed problems, and helps landowners.

- **Forest Stewardship Helpline** (Telephone: 1-800-738-TREE): This helpline can answer questions and provide referrals on any forest-related topic.

- **California Forest Improvement Program** (http://www.fire.ca.gov/ResourceManagement/CFIP.asp): The purpose of the California Forest Improvement Program (CFIP) program is to encourage private and public investment in, and improved management of, California’s forests and resources. This focus is to ensure adequate high-quality timber supplies; related employment and other economic benefits; and the protection, maintenance, and enhancement of a productive and stable forest resource system for the benefit of present and future generations. For more information, download the California Forest Improvement Program, *Users Guide* (http://www.ceres.ca.gov/foreststeward/html/CFIP.html#Anchor-Download-18066).

- **California Department of Forestry and Fire Protection's Fire and Resource Assessment Program (FRAP)** (http://frap.cdf.ca.gov/index.htm): FRAP assesses the amount and extent of California's forests and rangelands, analyzes their conditions, and identifies alternative management and policy guidelines.
- **USDA NRCS National Forestry Handbook and National Forestry Manual** ([link](http://www.nrcs.usda.gov/technical/ECS/forest)): The handbook and manual provide information for USDA NRCS personnel on forest planning and harvesting on nonpublic lands. The manual has information on the USDA NRCS Forest Policy.

- **North Coast Regional Water Quality Control Board (RWQCB)** ([link](http://www.swrcb.ca.gov/rwqcb1/programs/timber.html)): The North Coast RWQCB has been active in regulating discharges from logging, construction, and associated activities since 1972. Implementation of the Forest Practice Rules, which affect timber harvesting near streams, has a direct influence on water quality throughout the North Coast Region. The RWQCB staff perform regulatory activities including pre- and post-harvest inspections, watershed analysis, stream monitoring, and TMDL development.

- **California Department of Fish and Game** ([link](http://www.dfg.ca.gov/habitats/private.html)): The Department of Fish and Game provides information and recommendations to private landowners on programs and activities for the protection, management, and enhancement of native wildlife, fish, plants, and habitats. A variety of programs and partnerships between the State and private landowners are available. These initiatives could include timber management in the context of improving wildlife habitat.

- **USDA Forest Service** ([link](http://www.fireplan.gov/content/activity_in_your_state/?StateID=5&LanguageID=1)): The USDA Forest Service is working toward goals of the National Fire Plan to put information, materials, and funds in the hands of local organizations and communities. The State Fire Assistance program, with $3.6 million for California, helps build an optimal level of state firefighting capability, supports training and equipment for state firefighters, funds hazard mitigation projects on state and local land, and promotes Firewise training so homeowners can create defensible space and reduce fire risk around their homes and in their communities.
### 2.2.3 Management Measure 2A

**Preharvest Planning**

**Management Measure**

1. Perform advance planning for forest harvesting that includes the following elements where appropriate:

   **Element 1.** Identify (a) the area to be harvested including the location of water bodies and sensitive areas such as wetlands, threatened or endangered aquatic species habitat areas, or high-erosion-hazard areas (landslide-prone areas) within the harvest unit, and (b) the hydrologic unit where the project is located and the water bodies that the project is tributary to.

   **Element 2.** Time the activity for the season or moisture conditions to avoid degradation of water quality and prevent impacts on beneficial uses. Avoid any activities that cause soil disturbance or discharge from road surfaces during wet weather, except emergency maintenance work.

   **Element 3.** Consider potential water quality impacts and erosion and sedimentation control in the selection of silviculture and regeneration systems, especially for harvesting and site preparation.

   **Element 4.** Reduce the risk of landslides and severe erosion by identifying high-erosion-hazard areas and avoiding timber operations where they may exacerbate risk.

   **Element 5.** Consider cumulative effects from timber operations or roads on any known existing water quality impairments or problems in watersheds.

2. Perform advance planning for forest road systems that includes the following elements where appropriate:

   **Element 1.** Locate and design road systems to minimize potential sediment generation and delivery to surface waters. Key activities are (a) locate roads, landings, and skid trails to avoid steep grades and steep or unstable hillslope areas, and to decrease the number of stream crossings; (b) avoid to the extent practicable locating new roads and landings in Streamside Management Areas (SMAs); and (c) determine road usage and select the appropriate road standard.

   **Element 2.** Locate and design temporary and permanent stream crossings to prevent failure and control impacts from the road system. Key activities are (a) size, design, and site crossing structures to prevent failure and minimize diversion potential; and (b) design crossings to facilitate fish passage in fish-bearing streams.

   **Element 3.** Ensure that the design of the road prism and the road surface drainage is appropriate to the terrain and that road surface design is consistent with the road drainage structures.

   **Element 4.** Use suitable materials for surface roads planned for all-weather use to support truck traffic.

   **Element 5.** Design road systems to avoid high erosion or landslide hazard areas. Identify these areas and consult a qualified specialist for the design of any roads that must be constructed in these areas.
2.2.3.1 Programs
The California Department of Forestry and Fire Protection (CDF) enforces the laws that regulate logging on privately owned lands in California. These laws are found in the Forest Practice Act, which was enacted in 1973 to ensure that logging was done in a manner that would preserve California’s fish, wildlife, forests, and streams and other water sources forever. The Timber Harvesting Plan (THP) is the blueprint submitted by a landowner to CDF outlining what timber they want to harvest, how it will be harvested, and the steps that will be taken to prevent damage to the environment. CDF reviews and approves THPs (http://www.fire.ca.gov/ResourceManagement/THinCA.asp).

2.2.3.2 Management Practices
A Timber Harvest Plan must be prepared and submitted to the regional CDF director before timber is harvested for commercial purposes. A Registered Professional Forester (RPF) usually prepares a THP. The RPF preparing the plan will submit to the Director, with the plan, a Notice of Intent to Harvest Timber (Notice of Intent) under a number of circumstances where the timber harvest could have an effect on neighboring property or downstream water bodies (CDF, 2003, Article 2 and sections 1032-1037 of the California Forest Practice Rules). In addition to a Notice of Intent, a Cumulative Watershed Effects (CWE) analysis is now required as part of THPs in California. In evaluating cumulative impacts, the RPF considers factors such as the watershed(s) in which the site is located; soil productivity; biological, recreational, and visual resources; and traffic. Specific watershed factors to be addressed are sediment, water temperature, organic debris, chemical contamination, and peak flow. The CDF, as lead agency, makes the final determination regarding assessment sufficiency and the presence or absence of significant cumulative impacts. This determination is based on a review of all sources of information provided and developed during review of the THP (CDF, 2003).

There are numerous factors that should be considered when developing THPs and CWEs, but in general a thorough evaluation of the site should identify areas that require special protection, such as land adjacent to watercourses, steep slopes with high erosion potential, natural springs, wetlands, and areas that could provide habitat for endangered species. Site features to be protected and other considerations for developing THPs and CWEs are outlined in detail in USEPA’s draft National Management Measures to Control Nonpoint Source Pollution From Forestry (USEPA, 2002), which can be downloaded in PDF format from http://www.epa.gov/owow/nps/forestrymgmt/ (see Chapter 3, Section 3A Preharvest Planning).

2.2.3.3 Information Resources
- California Licensed Foresters Association (http://www.clfa.org/what_is_a_registered_professiona.htm): This Web site has information about contacting professional foresters.
- California Forest Practice Act (http://www.fire.ca.gov/ResourceManagement/pdf/2000RULE198254.pdf): The California Department of Forestry and Fire Protection (CDF) enforces the laws that regulate logging on privately owned lands in California. These laws are found in the Forest Practice Act, which was enacted in 1973 to ensure that logging was done in a manner that would preserve California’s fish, wildlife, forests, and streams and other water sources forever.
- California Forest Practice Rules (http://www.fire.ca.gov/ResourceManagement/pdf/FPR200301.pdf): The purpose of the Forest Practice Rules is to implement the provisions of the Forest Practice Act of 1973. The rules ensure that forestry practices are consistent with environmental quality programs in the State.

• **FishXing Web site** ([http://www.stream.fs.fed.us/fishxing/index.html](http://www.stream.fs.fed.us/fishxing/index.html)): This Web site provides software and learning systems for calculating fish passage through culverts (USEPA, 2002).

• **The USDA Forest Service’s Roads Analysis Procedure** ([http://www.fs.fed.us/r6/columbia/roads_analysis/roads_analysis_process_handbook.pdf#xml](http://www.fs.fed.us/r6/columbia/roads_analysis/roads_analysis_process_handbook.pdf#xml)): This procedure is designed to help national forest managers bring their road systems into balance with current social, economic, and environmental needs (USDA Forest Service, 1999). Roads Analysis uses a six-step procedure with a set of analytical questions to be used in tailoring analysis techniques to individual situations. Roads analysis is primarily a stand-alone procedure, but the conceptual framework and resources for analysis may be readily integrated into any analytical process in which the roads are examined.

### 2.2.3.4 Case Study

*The Casper Creek Experimental Watershed Study.* This watershed study on the Jackson Demonstration State Forest near Fort Bragg, California, is a cooperative venture of the Redwood Sciences Laboratory and the California Department of Forestry and Fire Protection. The study has been conducted continuously since 1962. The research focus is on learning more about how watersheds respond to logging. Research data on hydrology and sedimentation are available on the laboratory’s Web site ([http://www.rsl.psw.fs.fed.us/projects/water/caspar.html](http://www.rsl.psw.fs.fed.us/projects/water/caspar.html)).

### 2.2.3.5 References


### 2.2.4 Management Measure 2B
Streamside Management Areas

**Management Measure**

1. Establish and maintain a Streamside Management Area (SMA) along surface waters that is sufficiently wide and includes a sufficient number of canopy species to serve as a buffer against detrimental changes in the temperature regime of the water body, to provide bank stability, and to withstand wind damage.

2. Manage the SMA, including flood-prone areas, in such a way as to protect against soil disturbance in the SMA and delivery to the stream of sediments and nutrients generated by forestry activities, including harvesting.

3. Manage the SMA canopy species to provide a sustainable source of large woody debris needed for instream channel structure and aquatic species habitat.

### 2.2.4.1 Programs
California Department of Forestry and Fire Protection, Resource Management Program. Maintaining the sustainability of all of California’s natural resources is the goal of the CDF Resource Management Program. The Department achieves this goal by administering State and federal forestry assistance programs for landowners, demonstrating sound management practices on eight demonstration State forests, enforcing the California Forest Practice Act on all nonfederal timberlands, providing research and educational outreach to the public on forest pests such as Sudden Oak Death, and coordinating efforts for fuel reduction to reduce the risk of fire and improve the quality of California’s ecosystems. CDF’s mission emphasizes the management and protection of California’s natural resources. The Resource Management Program is an integral part of that responsibility ([http://www.fire.ca.gov/ResourceManagement/ResourceManagement.asp](http://www.fire.ca.gov/ResourceManagement/ResourceManagement.asp)).

Although SMAs can protect water quality, leaving timber for an SMA results in less timber harvested from the stand. Dykstra and Froehlich (1976) calculated that, in an Oregon timber sale, leaving an SMA 55 feet wide resulted in a 0 to 6 percent timber volume forgone per million board feet of timber. Likewise an SMA 150 feet wide resulted in 6 to 17 percent timber volume forgone.

### 2.2.4.2 Management Practices
Under the California Forest Practice Rules, SMAs are called Watercourse and Lake Protection Zones (WLPZs). A Registered Professional Forester (RPF) preparing the Timber Harvest Plan (THP) should conduct a field examination of all lakes and watercourses and map all lakes and watercourses that occur in the vicinity of the planned harvest.

The following are general practices that can be used to establish SMAs:

- **Evaluate sensitive conditions:** Evaluate areas near, and areas with the potential to directly impact, watercourses and lakes for sensitive conditions including existing and proposed roads, skid trails and landings, unstable and erodible watercourse banks, unstable upslope areas, debris, jam potential, inadequate flow capacity, changeable channels, overflow channels, flood prone areas, and riparian zones.
- **Spawning/rearing habitat:** Map the location of spawning and rearing habitat for anadromous salmonids, and evaluate the condition of the habitat using habitat typing that, at a minimum, identifies the pool, flatwater, and riffle percentages.

- **Establish a Watercourse and Lake Protection Zone:** Determine the required width of the WLPZ according to the guidelines in California Forest Practice Rules. WLPZs vary between 50 and 150 feet depending on the steepness of the terrain and the class of the watercourse the WLPZ is designed to protect.
  - Protect vegetation in the WLPZ: Within the WLPZ, retain at least 75 percent surface cover and undisturbed area to act as a filter strip, for raindrop energy dissipation, and for wildlife habitat. Mark trees in WLPZs before other preharvest activities begin to ensure retention of the shade canopy filter strip properties of the WLPZ and the maintenance of a multi-storied stand to protect water quality values. Provide for future large woody debris for instream habitat by retaining at least two living conifers per acre at least 16 inches diameter breast high and 50 feet tall within 50 feet of perennial streams.
  - Protect soils in WLPZs to prevent erosion: Treat exposed mineral soil in the WLPZ adjacent to perennial streams with mulch, riprap, grass seed, or chemical soil stabilizers to reduce soil loss. This does not apply to the traveled surface of roads. Where necessary to protect beneficial uses of water from timber operations, use protection measures such as seeding, mulching, or replanting to retain and improve the natural ability of the ground cover within the standard width of the WLPZ to filter sediment, minimize soil erosion, and stabilize banks of watercourses and lakes.

- **Establish an Equipment Limitation Zone:** Where operations occur adjacent to certain watercourses, designate an Equipment Limitation Zone (ELZ) where required by the California Forest Practice Rules. Excluding heavy equipment from streamside areas helps to prevent soil disturbance, erosion, and sedimentation in streams.

### 2.2.4.3 Information Resources

- **Southern California National Forest Management Plan Revisions** ([http://www.sw-center.org/swcbd/Programs/forests/so-cal-forest-plans.html](http://www.sw-center.org/swcbd/Programs/forests/so-cal-forest-plans.html)): The 400-plus page Conservation Alternative is a scientifically based forest management plan that emphasizes the value of preserving species, ecosystems, habitat, watersheds, and wilderness as well as maintaining opportunities for low-impact recreation in the most highly visited national forests in the nation.

- **Department of Forestry and Research, Mississippi State University, Streamside Management Zones (SMZs)** ([http://www.cfr.msstate.edu/fwrc/forestry/streamside.htm](http://www.cfr.msstate.edu/fwrc/forestry/streamside.htm)): The Departments of Forestry and Wildlife and Fisheries embarked on a project designed to evaluate the effectiveness of SMZs in protecting the water quality and habitat that support fish and macroinvertebrate populations in 15 streams in north-central Mississippi.

### 2.2.4.4 Case Study

*The Use of Alternative Buffers and Filter Strips in Oregon.* The costs associated with the use of alternative buffers and filter strips were analyzed in an Oregon study (Olsen, 1987). In that study, increasing the SMA width from 35 feet on each side of a stream to 50 feet reduced the value per acre by $75 (discounted cost) to $103 (undiscounted cost), or an approximate 2 percent increase in harvesting cost per acre (from $3,163 discounted to $5,163 undiscounted). Doubling the SMA width from 35 to 70 feet on each side of a stream reduced the dollar value per acre by approximately three times, adding approximately 8 percent to the discounted harvesting costs (USEPA, 2002).
2.2.4.5 References
2.2.5 Management Measure 2C
Road Construction/Reconstruction

Management Measure

1. Follow preharvest planning (as described under Management Measure 2A) when constructing or reconstructing roadways.

2. Follow designs planned under Management Measure 2A for road surfacing and shaping.

3. Install road drainage structures according to designs planned under Management Measure 2A and regional storm return period and installation specifications. Match these drainage structures with terrain features and with road surface and prism designs.

4. Guard against the production of sediment when installing stream crossings.

5. Protect surface waters from slash and debris material from roadway clearing.

6. Use straw bales, silt fences, mulching, or other favorable practices on disturbed soils on cuts, fill, etc.

7. Avoid constructing new roads in SMAs to the extent practicable.

2.2.5.1 Programs
California Department of Forestry and Fire Protection, Resource Management Program. Maintaining the sustainability of California’s natural resources is the goal of the CDF Resource Management Program. The Department achieves this goal by administering State and federal forestry assistance programs for landowners, demonstrating sound management practices on eight demonstration State forests, enforcing the California Forest Practice Act on all nonfederal timberlands, providing research and educational outreach to the public on forest pests such as Sudden Oak Death, and coordinating efforts for fuel reduction to reduce the risk of fire and improve the quality of California’s ecosystems. CDF’s mission emphasizes the management and protection of California’s natural resources. The Resource Management Program is an integral part of that responsibility (http://www.fire.ca.gov/ResourceManagement/ResourceManagement.asp).

The USDA Forest Service adopted a new road management policy in January 2001, which directs the agency to maintain a safe, environmentally sound road network that is responsive to public needs and affordable to manage. The policy includes a science-based roads analysis process designed to help managers make better decisions on roads. The USDA Forest Service is looking at ways to make the road management policy work better and is conducting an internal review of the policy (http://www.fs.fed.us/eng/road_mgt/index.shtml).
2.2.5.2 Management Practices

Logging roads and landings have the potential to be one of the greatest sources of sediment from managed forestlands. According to the California Forest Practice Rules, all logging roads and landings in the logging area need to be planned, located, constructed, reconstructed, used, and maintained in a manner that is consistent with long-term enhancement and maintenance of the forest resource and that prevents degradation of water quality.

Existing roads should be used whenever possible and new roads should be laid out in systematic patterns to reduce overall mileage. To reduce disturbance to natural site features, new roads should be tailored to the natural topography and should not be placed in unstable areas that are subject to erosion or deterioration, such as near canyon bottoms or through wetlands. Ideally they would be located on natural benches, flatter slopes, and areas of stable soils to minimize effects on watercourses.

2.2.5.3 Information Resources

- **California Forest Stewardship Program. Proper Road Design Minimized Stream Impacts** (http://ceres.ca.gov/foreststeward/html/roads.html): This fact sheet provides information on properly designing forest roads.

- **California Forest Stewardship Program. Preparing Your Road for Rain** (http://ceres.ca.gov/foreststeward/html/prepare.html): This fact sheet provides information on reducing runoff pollution from forest roads.

- **USDA Forest Service, Road Management Policy** (http://www.fs.fed.us/eng/road_mgt/policy.shtm): In 2001, the USDA Forest Service published a final policy governing the national forest transportation system. This Web site provides links to the policy and interim direction revising the policy.

- **Geomorphic Impacts of Culvert Replacement and Removal** (http://www.clfa.org/CulvertReplacementGuidelines21103.pdf): These guidelines are used by the U.S. Fish and Wildlife Service in culvert replacement and removal projects, and are recommended practices for the design and construction of stream crossings. These guidelines serve to assist with any culvert-related endangered species consultation requirements. Compliance with these guidelines should help minimize or avoid impacts during project construction activities and result in long-term benefits to threatened or endangered species.

- **SEDMODL** (http://frap.cdf.ca.gov/projects/nchip_sediment/abstractframes.html): Previous studies in forested watersheds in northern California have shown that the location and condition of road within a watershed can have a significant effect on the amount of erosion associated with the road system. A road sedimentation model, SEDMODL, was applied to the Caspar Creek watershed on the Jackson Demonstration State Forest. The model was run on Caspar Creek to evaluate the contribution of roads as part of the basin's sediment budget and to assist in identifying roads that produce relatively high amounts of sediment.

- **Mendocino County Resource Conservation District, Handbook for Forest and Ranch Roads.** (June 1994). This document is a guide and field manual for anyone involved with roads in forests or on ranches. It contains many helpful photographs and illustrations, charts, and tips on approaching road building from planning through construction, maintenance, and closure. The publication can be requested by calling the Mendocino County Resource Conservation District (Telephone: 707-468-9223).
2.2.5.4 Case Study

Fisher Creek Watershed Improvement Project. As part of this project in the Payette National Forest, Idaho, Rygh (1990) examined the costs of ripping and scarification using different techniques and specifically compared the relative advantages of using track hoes for ripping and scarification versus using large tractor-mounted rippers. Track hoes were found to be preferable to tractor-mounted rippers for a variety of reasons, including the following:

- A reduction in furrows and resulting concentrated runoff caused by tractors
- Improved control over the extent of scarification
- Increased versatility and maneuverability of track hoes
- Cost savings

The study concluded that the cost of ripping with track hoes ranged from $406 to $506 per mile compared with $686 per mile for ripping with D7 or D8 tractors (1998 dollars).

2.2.5.5 References


2.2.1 Management Measure 2D
Road Management

Management Measure

1. Avoid using roads for timber hauling or heavy traffic during wet or thaw periods on roads not designed and constructed for these conditions.

2. Evaluate the future needs for a road and close roads that will not be needed. Leave closed roads and drainage channels in a stable condition to withstand storms.

3. Remove drainage crossings and culverts if there is a reasonable risk of plugging or failure from lack of maintenance.

4. After harvest, close and stabilize temporary spur roads and seasonal roads to control and direct water away from the roadway. Remove all temporary stream crossings.

5. Inspect roads to determine the need for structural maintenance. Conduct maintenance practices, when conditions warrant, including cleaning and replacement of deteriorated structures and erosion controls, grading or seeding of road surfaces and, in extreme cases, slope stabilization or removal of road fills where necessary to maintain structural integrity.

6. Conduct maintenance activities, such as dust abatement, so that contaminants or pollutants are not introduced into surface waters.

7. Properly maintain permanent stream crossings and associated fills and approaches to reduce the likelihood (a) that stream overflow will divert onto roads, and (b) that fill erosion will occur if the drainage structures become obstructed.

2.2.5.6 Programs
California Department of Forestry and Fire Protection, Resource Management Program. Maintaining the sustainability of California’s natural resources is the goal of the CDF Resource Management Program. The Department achieves this goal by administering State and federal forestry assistance programs for landowners, demonstrating sound management practices on eight demonstration State forests, enforcing the California Forest Practice Act on all nonfederal timberlands, providing research and educational outreach to the public on forest pests such as Sudden Oak Death, and coordinating efforts for fuel reduction to reduce the risk of fire and improve the quality of California’s ecosystems. CDF's mission emphasizes the management and protection of California's natural resources. The Resource Management Program is an integral part of that responsibility (http://www.fire.ca.gov/ResourceManagement/ResourceManagement.asp).

The USDA Forest Service adopted a new road management policy in January 2001, which directs the agency to maintain a safe, environmentally sound road network that is responsive to public needs and affordable to manage. The policy includes a science-based roads analysis process designed to help managers make better decisions on roads. The USDA Forest Service is looking at ways to make the road management policy work better and is conducting an internal review of the policy (http://www.fs.fed.us/eng/road_mgt/index.shtml).
2.2.5.7 Management Practices

Sound planning, design, and construction measures often reduce road maintenance needs after construction. Minimum maintenance is required of roads constructed with a minimum width in stable terrain and with frequent grade reversals or dips. Unfortunately, older roads remain one of the greatest sources of sediment from managed forestlands. After harvesting, roads are often forgotten, and erosion problems might go unnoticed until after severe resource damage has occurred (USEPA, 2002).

The following are practices that can be used to minimize the adverse environmental impact of logging roads:

- **Prescribed maintenance:** At a minimum of once per year, prescribed maintenance should be performed to control erosion on permanent, seasonal roads, landings, and drainage structures that are not abandoned.

- **Abandonment of temporary roads:** Temporary roads and associated landings should be abandoned upon completion of timber operations in accordance with existing CDF regulations.

- **Bridges, drainage structures, and berms:** Bridges and drainage structures should be kept open to the unrestricted passage of water. Drainage structures not adequate to carry water from the 50-year flood level should be removed in accordance with CDF regulations by the first day of the winter period before the flow of water exceeds their capacity if operations are conducted during the winter period, or by the end of timber operations ( whichever occurs first). Properly functioning drainage structures on roads that existed before timber operations need not be removed (CDF, 2003). Trash racks or similar devices can be installed where needed at culvert inlets in a manner that minimizes culvert blockage. Roadside berms should be removed from logging roads or breached before the beginning of the winter period, except where needed to control erosion. Drainage ditches should be maintained to allow free flow of water and minimize soil erosion. Each drainage structure and trash rack should be maintained and repaired as needed to prevent blockage and to provide adequate carrying capacity. Where not present, new trash racks can be installed if there is evidence that woody debris is likely to significantly reduce flow through a drainage structure.

- **Stable road surfaces:** Road surfaces should be treated as necessary during timber operations to prevent excessive loss of road surface materials using methods such as rocking, watering, chemically treating, asphalting, or oiling.

- **Slope protection:** Actions should be taken to prevent failures of cut, fill, or sidecast slopes. This may involve installing or renewing soil stabilization treatments on road or landing cuts, fills, or sidecast slopes when such treatment could minimize surface erosion that threatens the beneficial uses of water (CDF, 2003).

2.2.5.8 Information Resources

- **USDA Forest Service Roads Analysis:** Informing Decisions About Managing the National Forest Transportation System (http://www.fs.fed.us/eng/road_mgt/DOCsroad-analysis.shtml): This is a complete science-based roads analysis designed to inform management decisions about the benefits and risks of constructing new roads in unroaded areas; relocating, stabilizing, changing the standards of, or decommissioning, unneeded roads; access issues; and increasing, reducing, or discontinuing road maintenance.

- **California Forest Stewardship Program:** Preparing Your Road for Rain (http://ceres.ca.gov/foreststeward/html/prepare.html): This fact sheet provides information on reducing runoff pollution from forest roads.
California Forest Stewardship Program. Road Retirement
(http://ceres.ca.gov/foreststeward/html/unneeded.html): This fact sheet provides information on how to properly close forest roads.

SEDMODL, (http://frap.cdf.ca.gov/projects/nchip_sediment/abstractframes.html): Previous studies in forested watersheds in northern California have shown that the location and condition of a road within a watershed can have a significant effect on the amount of erosion associated with the road system. A road sedimentation model, SEDMODL, was applied to the Caspar Creek watershed on the Jackson Demonstration State Forest. The model was run on Caspar Creek to evaluate the contribution of roads as part of the basin's sediment budget and to assist in identifying roads that produce relatively high amounts of sediment.

Mendocino County Resource Conservation District, Handbook for Forest and Ranch Roads. This document is a guide and field manual for anyone involved with roads in forests or on ranches. It contains many helpful photographs and illustrations, charts, and tips on approaching road building from planning through construction, maintenance, and closure. This publication can be requested by calling the Mendocino County Resource Conservation District (Telephone: 707-468-9223).

USDA Forest Service, Water/Road Interaction Technology Series (http://www.stream.fs.fed.us/water-road/): This series offers an excellent discussion of the relationship between forest roads and drainage.

2.2.5.9 Case Study

Road Decommissioning. Abandoning roads without first performing corrective measures can create erosion problems that persist for decades. When a road is no longer needed, it can be restored to a more natural state by removing road improvements and reestablishing vegetation in a process called decommissioning. Road decommissioning can significantly reduce water quality effects from unused roads, and road closure and decommissioning can help realize many objectives and purposes (Harr and Nichols, 1993), including the following:

- Eliminate or discourage access to roads to reduce maintenance expenditures.
- Eliminate the potential for drainage structure failure and stream diversion.
- Reduce soil loss, embankment washout, mass wasting, failures, slides, slumps, sedimentation, turbidity, and damage to fish habitat.
- Provide cover and organic matter to soil, and improve the quality of wildlife and fish habitat.
- Enhance the visual qualities of road corridors and disturbed areas.
- Attempt to restore the natural pre-road hydrology to the site.

Road decommissioning can lead to improvements in fish habitats where sediment-laden runoff from old forest roads enters streams. The practice was used in a watershed in northwest Washington as part of watershed rehabilitation to improve fish habitats and water quality and to reduce flood hazards. On unused, 30- to 40-year-old, largely impassable roads and landings, fills were stabilized, stream crossings were removed, slopes were recontoured, and drainage patterns were reestablished at an average cost of $3,950 per kilometer (with a range of $1,500 to $7,500 per kilometer) (1998 dollars). Costs were lowest where little earthmoving was involved; costs were higher where a lot of brush had to be cleared away and sidecast material had to be pulled upslope, and highest where fills were removed at stream crossings and landings. Afterward, however, the obliterated roads and landings sustained much less damage from storms than unused roads that were not obliterated (Harr and Nichols, 1993).
2.2.5.10 References


2.2.6 Management Measure 2E
Timber Harvesting

Management Measure

The timber harvesting management measure consists of implementing the following:

1. General

Element 1. Conduct timber harvesting operations with skid trails or cable yarding following layouts determined under Management Measure 2A.

Element 2. Install landing drainage structures to minimize erosion and prevent sedimentation.

Element 3. Construct landings away from steep slopes and reduce the likelihood of fill slope failures. Protect landing surfaces used during wet periods. Locate landings outside Streamside Management Areas (SMAs).

Element 4. Protect stream channels and significant ephemeral drainages from logging debris and slash material.

Element 5. Use appropriate areas for petroleum storage and equipment maintenance and service. Establish procedures to contain and treat spills. Recycle or properly dispose of all waste materials.

2. For cable yarding

Element 1. Limit yarding corridor gouge or soil plowing by properly locating cable yarding landings.

Element 2. Locate corridors for SMAs following Management Measure 2B.

3. For groundskidding

Element 1. Within SMAs, operate ground-skidding equipment only at stream crossings. In SMAs, fell and endline trees to avoid sedimentation and damage to residual vegetation.

Element 2. Use improved stream crossings for skid trails that cross flowing drainages. Construct skid trails to disperse runoff and with adequate drainage structures.

Element 3. On steep slopes, use cable systems rather than ground-skidding where ground-skidding may cause excessive erosion.

2.2.6.1 Programs

The California Department of Forestry and Fire Protection (CDF) enforces the laws that regulate logging on privately owned lands in California. These laws are found in the Forest Practice Act, which was enacted in 1973 to ensure that logging was done in a manner that would preserve California’s fish, wildlife, forests, and streams and other water sources forever (http://www.fire.ca.gov/ResourceManagement/THinCA.asp).
The USDA Forest Service’s National Forest Timber Harvest must conform to the 1976 National Forest Management Act (NFMA). The NFMA requires that each national forest develop a comprehensive plan, using substantial public involvement and sound science, to guide future management. Many national forests are now working to revise those plans by addressing inadequacies, new information, changed conditions, and/or new issues or trends. More information on forest management in the California National Forests is available at http://www.fs.fed.us/r5/forests.html.

2.2.6.2 Management Practices

The following are practices that can be used to minimize the adverse environmental impacts of timber harvest:

- **Felling trees**: Trees should be felled in a direction away from watercourses and lakes. Also, damage to desirable residual trees and tree seedlings of commercial species should be avoided during felling and while operating heavy equipment. Slash and debris from timber operations should not be bunched adjacent to residual trees required for silvicultural or wildlife purposes or placed in locations where they could be discharged into a Class I or II watercourse or lake (CDF, 2003).

- **Skidding logs**: Logs should be skidded uphill to log landings whenever possible, and the ends of the logs should be raised to reduce rutting and gouging. This practice disperses water on skid trails away from the landing. Skidding uphill lets water from trails flow onto progressively less-disturbed areas as it moves downslope, reducing the likelihood of erosion. Skidding downhill concentrates surface runoff on lower slopes along skid trails, resulting in significant erosion and sedimentation hazard (USEPA, 2002). If it is not possible to skid uphill, logs should be skidded along the contour (perpendicular to the slope), and skidding should be avoided on slopes greater than 40 percent. Following the contour reduces soil erosion and encourages revegetation. Skid trail layouts that concentrate runoff into draws, ephemeral drainages, or watercourses and skidding up or down ephemeral drainages should be avoided. Endlining, using care to avoid soil plowing or gouging, should be used to winch logs out of SMAs, or, alternatively, trees can be felled directionally so the tops extend out of SMAs, allowing the trees to be skidded without having to operate equipment within the SMAs. Ground skidding should be suspended during wet periods, when excessive rutting and churning of the soil begins, or when runoff from skid trails is turbid and no longer infiltrates within a short distance from the skid trail. Further limitation of ground skidding of logs, or the use of cable yarding, might be needed on slopes where there are sensitive soils and/or during wet periods.

- **Heavy equipment operation**: Tractors should be operated in a manner that complies with CDF regulations. Heavy equipment with a blade should not be operated on skid roads or slopes that are so steep as to require the use of the blade for braking. Heavy equipment should not be used on slopes steeper than 65 percent, slopes steeper than 50 percent where the erosion hazard rating is high or extreme, and slopes over 50 percent that lead without flattening to sufficiently dissipate water flow and trap sediment before it reaches a watercourse or lake. Heavy equipment should also not be used on unstable areas, but if such areas are unavoidable, the Registered Professional Forester (RPF) should develop specific measures to minimize the effect of operations on slope instability.

- **Roads**: Tractor roads should be limited to the minimum necessary extent and width for removal of logs. Existing tractor roads should be used instead of constructing new tractor roads. Where
tractor roads are constructed, timber operators should use tractor roads only, both for skidding logs to landings and on return trips.

- **Spill prevention and waste management:** Equipment used in timber operations should not be serviced in locations where servicing will allow grease, oil, or fuel to pass into lakes or watercourses. Non-biodegradable refuse, litter, trash, and debris resulting from timber operations should be disposed of in a manner approved by State and local authorities. Practices should be implemented that prevent mobilization by rainfall or runoff of pollutants from wastes that are temporarily stored on the site.

- **Cable yarding:** The natural topography and timber types should be used to maximum efficiency so that cable yarding operations protect residual trees. Residual trees required to be left upon completion of timber operations should not be used for rub trees, corner blocks, rigging, or other cable ties unless effectively protected from damage. Tight-lining for the purpose of changing location of cable lines should not be used unless such practice can be carried on without damaging residual trees. Tractors should not be used in areas designated for cable yarding except to pull trees away from streams, to yard logs in areas where deflection is low, to construct firebreaks and/or layouts, and to provide tail-holds. Cabling systems or other systems should be used when ground skidding would expose excess mineral soil and induce erosion and sedimentation. Use high-lead cable or skyline cable systems on slopes greater than 40 percent and on average-profile slopes of less than 15 percent (the latter to avoid soil disturbance from sidewash).

Cable yarding should be avoided in or across watercourses. When cable yarding across streams cannot be avoided, full suspension should be used to minimize damage to channel banks and vegetation in the SMA. Cableways should be cut or cleared across SMAs where SMAs must be crossed. This reduces the damage to trees remaining and prevents trees next to the stream channel from being uprooted.

- **Waterbreaks:** Waterbreaks should be installed on skid trails and tractor roads no later than the beginning of the winter period of the current year of timber operations. If logging occurs during the winter, waterbreaks should be installed before the end of the day if the U.S. Weather Service forecasts a “chance” (30 percent or more) of rain before the next day, and prior to weekends or other shutdown periods. Waterbreaks should be constructed concurrently with the construction of firebreaks and immediately upon conclusion of use of tractor roads, roads, layouts, and landings that do not have permanent and adequate drainage facilities, or drainage structures. Waterbreaks should be cut diagonally a minimum of 15.2 centimeters (cm) (6 inches) into the firm roadbed, cable road, skid trail, or firebreak surface, and a continuous firm embankment of at least 15.2 cm (6 in.) in height should be shaped immediately adjacent to the lower edge of the waterbreak cut. According to California Forest Practice Rules, the maximum permitted distance between waterbreaks is based upon the road gradient and soil erosion hazard rating, and varies from 50 to 300 feet.

Waterbreaks should be located to allow water to be discharged into some form of vegetative cover, duff, slash, rocks, or less erodible material. They should be constructed so that water will be discharged and spread to minimize erosion. Where waterbreaks cannot effectively disperse surface runoff, other erosion controls should be installed as needed to comply with CDF regulations. Waterbreaks or any other erosion controls should be maintained on skid trails, cable roads, layouts, firebreaks, abandoned roads, and site preparation areas during the prescribed maintenance period and during timber operations, or at least once per year. The CDF may
prescribe a maintenance period extending 3 years after timber operations are complete (CDF, 2003).

- **Watercourse crossings:** Watercourse-crossing facilities on tractor roads should be kept to a minimum. A prepared watercourse crossing using a structure such as a bridge, culvert, or temporary log culvert can be used to protect the watercourse from siltation where tractor roads cross a watercourse. Crossings should be designed to allow for the unrestricted passage of all life stages of fish that could be present in the watercourse. Watercourse-crossing facilities on tractor roads not constructed to permanent crossing standards should be removed before the beginning of the winter period.

- **After harvesting:** Skid trails should be retired by installing water bars or other erosion control and drainage devices, removing culverts, and mulching and reseeding. Logging slash should be distributed through the skid trails to supplement the water bars. Cross drains can be built on abandoned skid trails to protect stream channels or side slopes. Logging slash should be distributed throughout skid trails to supplement water bars and seeding to reduce erosion on skid trails.

### 2.2.6.3 Information Resources

- **California Forest Stewardship Program, Salvage Timber Harvesting Considerations** ([http://ceres.ca.gov/foreststeward/html/salvage.html](http://ceres.ca.gov/foreststeward/html/salvage.html)): This fact sheet provides information on salvage harvesting.


- **USEPA, Watershed Academy Web: Forestry Best Management Timber Harvesting** ([http://www.epa.gov/watertrain/forestry/sube1.htm](http://www.epa.gov/watertrain/forestry/sube1.htm)): This Web site serves as a forestry management module, with a series of interactive fact sheets on forestry management practices. The Web site includes diagrams, photographs, and review questions.

- **Wisconsin Department of Natural Resources, Timber Harvesting** ([http://www.dnr.state.wi.us/org/land/forestry/usesof/bmp/bmptimberharvesting.htm#Planning](http://www.dnr.state.wi.us/org/land/forestry/usesof/bmp/bmptimberharvesting.htm#Planning)): This fact sheet, part of Wisconsin’s BMP Field Manual, provides information on management practices related to timber harvesting.


- **Wisconsin Department of Natural Resources and University of Wisconsin, Madison, Department of Forestry, Timber Harvesting** ([http://forest.wisc.edu/extension/publications/7.pdf](http://forest.wisc.edu/extension/publications/7.pdf)): This fact sheet is part of Wisconsin’s Forestry Best Management Practices for Water Quality series, Forestry Facts. It provides information on timber harvesting practices to protect water quality.

comprehensive manual contains clear, well-organized background information and fact sheets on timber harvesting, as well as related management practices.

2.2.6.4 Case Study

*NPS Impacts from Forestry Activities.* The amount of soil disturbance caused by yarding depends on the slope of the area, the volume yarded, the size of the logs, and the logging system. A study by Megahan (1980) ranked yarding techniques based on percent area disturbed per yarding technique. Aerial and skyline cable techniques were found to be far less damaging than other yarding techniques. Percent soil disturbance results were as follows: tractor (21 percent average), ground cable (21 percent, one study), high-lead (16 percent average), skyline (8 percent average), jammer in clear cut (5 percent, one study), and aerial techniques (4 percent average).

*Impacts of Forest Practices on Surface Erosion.* The amount of road needed to harvest timber also varies considerably with yarding technique. A study by Sidle (1980) examined the amount of road area needed for different timber yarding techniques. Skyline techniques were found to use the least amount of road area, with only 2 to 3.5 percent of the land area required for roads. Tractor and single-drum jammer techniques used the greatest amount of road area (10 to 15 percent and 18 to 24 percent of total area, respectively). High-lead cable techniques fell in the middle, with 6 to 10 percent of the land used for roads. Compared with the skyline and aerial techniques, the tractor, jammer, and high-lead cable methods resulted in significantly higher amounts of disturbed soil (Megahan, 1980).

2.2.6.5 References


2.2.7 Management Measure 2F
Site Preparation and Forest Regeneration

Management Measure

Confine onsite potential NPS pollution and erosion resulting from site preparation and the regeneration of forest stands. The components of the management measure for site preparation and regeneration are as follows:

1. Select a method of site preparation and regeneration suitable for the site conditions.
2. Conduct mechanical tree planting and ground-disturbing site preparation activities on the contour of sloping terrain.
3. Do not conduct mechanical site preparation and mechanical tree planting on Streamside Management Areas (SMAs).
4. Protect surface waters from logging debris and slash material.
5. Suspend operations during wet periods.
6. Locate windrows at a safe distance from drainages and SMAs to control movement of the material during high runoff conditions.
7. Conduct bedding operations in high-water-table areas during dry periods of the year. Conduct bedding in sloping areas on the contour.
8. Protect small ephemeral drainages when conducting mechanical tree planting.

2.2.7.1 Programs

California Department of Forestry and Fire Protection, Resource Management Program. Maintaining the sustainability of California’s natural resources is the goal of the CDF Resource Management Program. The Department achieves this goal by administering State and federal forestry assistance programs for landowners, demonstrating sound management practices on eight demonstration State forests, enforcing the California Forest Practice Act on all nonfederal timberlands, providing research and educational outreach to the public on forest pests such as Sudden Oak Death, and coordinating efforts for fuel reduction to reduce the risk of fire and improve the quality of California’s ecosystems. CDF’s mission emphasizes the management and protection of California’s natural resources. The Resource Management Program is an integral part of that responsibility (http://www.fire.ca.gov/ResourceManagement/ResourceManagement.asp).

The Forestry Incentives Program (FIP) is a cooperative program involving the California Department of Forestry and Fire Protection, the Natural Resources Conservation Service, and the USDA Forest Service. FIP’s purpose is to enhance the productivity of private, nonindustrial forestland by providing financial and technical assistance for timber stand improvement and reforestation, such as site preparation and seedling planting (http://www.fire.ca.gov/ResourceManagement/ForestryIncentiveProgram.asp).
2.2.7.2 Management Practices

The goals of site preparation activities are to encourage maximum timber productivity, minimize fire hazards, prevent substantial adverse effects on soil resources and on fish and wildlife habitat, and prevent degradation of water quality. Site preparation has both short- and long-term components. Short-term goals can include treating logging slash to reduce the risk of wildfire and eliminate habitat for disease organisms. Long-term goals are aimed at creating conditions favorable to growing the next rotation of desired timber species. Site preparation and regeneration techniques influence the concentration of nutrients, pesticides, and sediment in runoff several years after timber harvest.

Site Preparation Practices

- **Timber harvest plan addendum:** Where site preparation will occur on the logging area, site preparation details should be included in an addendum to the timber harvest plan (THP). Relevant details include the general methods of site preparation to be used, the types of equipment, if any, to be used for mechanical site preparation and firebreak construction, the methods for protecting any desirable residual trees in accordance with CDF regulations, a map identifying the boundaries of site preparation areas, and a timetable of site preparation operations.

- **Streamside Management Areas:** Provide SMAs of sufficient width to protect streams from sedimentation by the 10-year storm and do not conduct mechanical site preparation in SMAs.

- **Runoff control and dispersal:** Use undisturbed areas to control and disperse concentrated runoff from roads, landings, tractor roads, firebreaks, and erosion control facilities where it flows into site preparation areas.

- **Slash management:** Logging slash that poses a fire hazard to homes, roads, or recreation areas should be lopped, removed, chipped, or piled and burned according to CDF regulations. Broadcast burning should be conducted so that it does not fully consume the larger organic debris that retains soil on slopes and stabilizes watercourse banks. Slash should not be placed in perennial or intermittent drainages, and any slash that accidentally enters drainages should be removed. Slash can clog the channel and cause alterations in drainage configuration and increases in sedimentation, and extra organic material can lower the dissolved oxygen content of the stream. Slash also allows silt to accumulate in the drainage and to be carried into the stream during storm events.

- **Windrows:** These should be located a safe distance from drainages to prevent material from moving into the drainages during high-flow conditions. Locating windrows above the 50-year floodplain usually prevents windrowed material from entering floodwaters.

- **Pest control:** Timber operations should be conducted in such a way as to minimize the buildup of destructive insect populations and the spread of forest diseases. Site preparation measures should be carried out to mitigate adverse infestation or infection impacts from the timber operation. Insects breeding in pine logging slash can be a significant problem. Measures to reduce insect diseases include removing logging slash from the site, piling and burning, chipping, debarking, treating with an appropriate pesticide, or piling and covering the slash with clear plastic.

- **Erosion control:** Soil movement should be minimized when shearing, piling, or raking. Incorporation of soil material into windrows and piles during their construction should be avoided. A rake, rather than a blade, should be used to move slash. If using a blade is unavoidable, the blade should be kept above the soil surface. This helps retain nutrient-rich
topsoil, which promotes rapid site recovery and tree growth and increases the effectiveness of the windrow in minimizing sedimentation.

- **Heavy equipment**: Heavy equipment for site preparation should not be used under saturated soil conditions. Mechanical site preparation (except drum chopping) should not be conducted on slopes greater than 30 percent. On sloping terrain greater than 10 percent, or on highly erosive soils, mechanical site preparation equipment should be operated on the contour.

*Forest Regeneration Practices*

USEPA (1993) recommends that seedlings be distributed evenly across the site and be ordered well in advance of planting time to ensure their availability. On highly erodible sites and steep slopes, and within SMAs, it is recommended that seedlings be planted by hand rather than using heavy equipment. Heavy equipment used in other areas should be operated along the contour of the slope to avoid forming ditches that can concentrate runoff and exacerbate erosion. Machines should not be operated on soils with steep slopes or excess moisture because they can become unstable and result in erosion or mass wasting, which could lead to injuries or pollution. Slits dug for planting seedlings should be closed at numerous points along their length to reduce the likelihood of channeling flows.

### 2.2.7.3 Information Resources

- **California Forest Stewardship Program, Developing Your Forest Stewardship Plan** ([http://ceres.ca.gov/foreststeward/html/stewardplan.html](http://ceres.ca.gov/foreststeward/html/stewardplan.html)): This fact sheet provides information on the benefits of a forest stewardship plan.

- **Wisconsin Department of Natural Resources and University of Wisconsin, Madison, Department of Forestry, Site Preparation and Tree Planting** ([http://forest.wisc.edu/extension/publications/8.pdf](http://forest.wisc.edu/extension/publications/8.pdf)): This fact sheet is part of Wisconsin’s Forestry Best Management Practices for Water Quality series, Forestry Facts. It provides information on site preparation and tree planting to protect water quality.


### 2.2.7.4 Case Study

*Impact of Forest Management on Northern Forest Soils.* Ballard (2000) reviewed the effects of forest management on forest soils. Mechanical site preparation, he noted, has benefits and causes problems. Nutrient depletion is one adverse effect. A study in northern British Columbia concluded that 500 kilograms of nitrogen per hectare were removed on a large area that had been bladed, raked, and piled for burning. However, Piatek and Allen (2000) found that the nutrients removed during site preparation had no observable effect on foliage production when measured 15 years after planting on the site.
Economic Impacts of Erosion Control in Forests. Dissmeyer (1986) analyzed the economic benefits of controlling erosion during site preparation. Site preparation methods that increased soil exposure, displacement, and compaction increased site preparation costs and erosion from the site prepared and decreased timber production. Light site preparation techniques such as a single chop and burn reduced erosion, increased timber production on the site, and cost less per unit area treated than more intensive site preparation methods. Heavy site preparation techniques such as shearing and windrowing removed nutrients, compacted soil, increased erosion and site preparation costs, and resulted in a lower present net value of timber.

2.2.7.5 References


2.2.8 Management Measure 2G
Fire Management

Management Measure
Prescribe fire for site preparation and control or suppress wildfire in a manner that reduces potential NPS pollution of surface waters.

1. Intense prescribed fire should not cause excessive erosion due to the combined effect of removal of canopy species and the loss of soil-binding ability of subcanopy and herbaceous vegetation roots, especially in Streamside Management Areas (SMAs), in streamside vegetation for small ephemeral drainages, or on very steep slopes.

2. Prescriptions for prescribed fire should protect against excessive erosion or prevent sedimentation.

3. All bladed fire lines, for prescribed fire and wildfire, should be plowed on contour or stabilized with water bars and/or other appropriate techniques if needed to control excessive sedimentation or erosion of the fire line.

4. Rehabilitation and salvage logging areas burned by wildfires should be managed to minimize erosion and prevent sedimentation.

2.2.8.1 Programs
The Vegetation Management Program (VMP) administered by the California Department of Forestry (CDF) is a cost-sharing program that focuses on the use of prescribed fire, and mechanical means, for addressing wildland fire fuel hazards and other resource management issues on State Responsibility Area (SRA) lands (http://www.fire.ca.gov/ResourceManagement/VegetationManagement.asp).

The California Fire Plan is the State’s road map for reducing the risk of wildfire. By placing the emphasis on what needs to be done long before a fire starts, the Fire Plan looks to reduce fire fighting costs and property losses, increase firefighter safety, and contribute to ecosystem health. The California Fire Plan is a cooperative effort between the State Board of Forestry and Fire Protection and the CDF (http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/FirePlan.asp).

The CDF’s Fire Emergency and Response team responds to wildfires within the State (http://www.fire.ca.gov/FireEmergencyResponse/FireEmergencyResponse.asp).

The CDF’s Fire and Resource Assessment Program assesses the amount and extent of California's forests and rangelands, analyzes their conditions, and identifies alternative management and policy guidelines (http://frap.cdf.ca.gov/index.htm).
2.2.8.2 Management Practices

Fire management practices are changing as the benefits of fire to forest ecosystems are becoming more widely accepted. Prescribed burning reduces hazardous fuels and reduces the potential for crown fires that kill timber trees. Fire is also essential for forest management where tree species are ecologically dependent on fire for regeneration or maintenance of healthy stands (USEPA, 2002). However, prescribed fire used for site preparation, fuel hazard reduction, and activities associated with wildfire suppression can sometimes create NPS pollution and erosion. The following management measures can be used to reduce the adverse impacts of fire on water quality:

- **Fire intensity**: High-intensity fires should be avoided, especially severe burns on steep slopes or highly erodible soils. High-intensity fires that remove vegetation and litter down to the mineral soil are most likely to adversely affect water quality. Furthermore, chemical changes in the soil following fire may create an increased resistance to water infiltration in the upper soil layer, and this can increase surface runoff and sheet erosion (USEPA, 2002). Periodic, low-intensity prescribed fires should be used to reduce the forest fuel loads. Low-intensity fires usually have little effect on water quality because burned areas with an intact litter layer yield little sediment and revegetate more quickly.

- **Timing of prescribed burns**: Burning should be planned to take into account weather, time of year, and fuel conditions so that these factors help achieve the desired results and minimize effects on water quality.

- **Logistics of prescribed burns**: The prescribed burn should be executed with an agency-qualified crew and burn boss. Burning permits must be obtained before burning. Every year, if required, either before April 1 or before the start of timber operations, a fire suppression resources inventory should be submitted to the CDF.

- **SMAs and wetlands**: Prescribed burning and site preparation activities that involve piling and burning for slash removal should not be conducted in SMAs. When applying prescribed fire in wetlands, burns should be conducted in a manner that does not completely remove the organic layer of the forest floor. Prescribed burns conducted in wetlands have the potential to be the most severe because of the increased fuels available. The fire should be conducted to minimize the potential to increase surface runoff and soil erosion. Fire lines should not be placed in sensitive areas such as wetlands, marshes, prairies, and savannas unless absolutely necessary.

- **Fire lines**: Fire line construction involves removing all organic material to expose mineral soil, and this can result in excessive erosion and water quality degradation. Natural or in-place barriers (e.g., roads, streams, and lakes) should be used to minimize the need for fire line construction in situations where construction of artificial fire lines could result in excessive erosion and sedimentation. Conditions that require extensive blading of fire lines with heavy equipment should be avoided when planning burns. Hand lines, firebreaks, and hose lays should be used to minimize blading of fire lines.

Fire lines need to be constructed in a manner that minimizes erosion and sedimentation and prevents runoff from directly entering watercourses. When crossing water bodies with plowing equipment, the plow should be raised to prevent connecting the fire line directly to the water body. Water bodies can be used as fire lines to avoid unnecessarily disturbing riparian zones. Also, construction of fire lines straight up and down hill should be avoided. The location of fire lines should be balanced with the potential for a larger fire that would consume greater amounts...
of material. Where possible, alternatives to plowed lines such as harrowing, foam lines, wet lines, or permanent grass should be considered.

- **Revegetation**: Once the fire is put out, vegetative cover on fire lines and disturbed areas should be reestablished as soon as possible using native species, as feasible, to control soil erosion.

- **Runoff controls**: Grades, ditches, and water bars to fire lines should be installed as soon as it is safe to begin rehabilitation work. Water bars should be installed on any fire line running up and down the slope, and runoff should be directed onto a filter strip or sideslope, not into a drainage area.

- **Fire retardants**: Whenever possible, a 300-foot buffer should be left on both sides of a waterway when fire retardants are applied from the air. If it is necessary to apply retardant within the 300-foot zone, the application method that most accurately keeps the retardant from entering the stream should be used. Fire retardant chemicals that contain sodium ferrocyanide should be avoided because a recent study revealed that mixtures with the chemical can decompose to produce amounts of cyanide that exceed USEPA water quality guidelines for freshwater organisms.

- **Fire detection/prevention**: A diligent aerial or ground inspection should be conducted within the first 2 hours after cessation of felling, yarding, or loading operations each day during the dry period when fire is likely to spread. The person conducting the inspection should have adequate communication available for prompt reporting of any fire that may be detected (CDF, 2003).

Laws and ordinances prohibiting or otherwise regulating smoking should be obeyed and smoking by persons engaged in timber operations should be limited to occasions when they are not moving about and are confined to cleared landings and areas of bare soil at least 3 feet in diameter.

- **Public safety**: Management practices for fire lines, road construction, and stream crossings should be suspended during wildfire emergencies to benefit public safety and should be restored as soon as possible. Remediation should begin after the emergency is controlled.

Costs associated with prescribed fire depend on the size of the fire crew, the amount of heavy equipment needed at the site to control the burn, the areal extent and intensity of the burn, and the topography of the area being burned. Costs for prescribed burning vary from approximately $80 to $500 per acre; costs are higher in mountainous terrain than on flat land (USEPA, 2002).

### 2.2.8.3 Information Resources


- **Protect Your Forest from Wildfire** ([http://ceres.ca.gov/foreststeward/html/protectforest.html](http://ceres.ca.gov/foreststeward/html/protectforest.html)): This Web site provides information on protecting private land from wildfires.

- **California Fire and Resource Assessment Program, Fire Management for California Ecosystems** ([http://frap.cdf.ca.gov/projects/fire_mgmt/fm_main.html](http://frap.cdf.ca.gov/projects/fire_mgmt/fm_main.html)): This paper discusses the use of an ecosystem management focus for fire management.
2.2.8.4 Case Study

Cone Fire in Lassen National Forest. The Cone Fire that occurred September 2002 on the Lassen National Forest (NF) provided wildland fire experts and forestry researchers a way to study the effects of fuel treatments on an active wildfire. Areas in the Lassen NF had been managed with different forest fuel treatments over the years, including prescribed fire and tree thinning. Initial observations indicate that high intensity burns occurred in areas that had received no management with thinning or prescribed fire. The timber stands that had been treated with thinning, prescribed fire, or both, experienced a low-intensity ground fire, resulting in lower tree mortality. Some treatments were observed to be very effective in slowing, and sometimes even stopping, the fire (http://www.cafirealliance.org/success_conefire.php).

Gasquet Community Fire Protection Successes. The community of Gasquet in the Smith River National Recreation Area, Six Rivers National Forest, had been identified as a community at risk from wildfire. In the spring on 1996, fuel reduction activities were implemented in forest lands surrounding the community in an area called the Gasquet Shaded Fuelbreak. Prescribed fire reduced the density of smaller branches, twigs, and needles, which are known to foster the spread of fire. In September 1996, the Panther Fire threatened Gasquet. When the Panther Fire burned into the Gasquet Shaded Fuelbreak, the fire lost intensity, allowing fire crews to contain the advancing head of the fire. No structures in Gasquet were lost or damaged (http://www.cafirealliance.org/success_nfp.php).

2.2.8.5 References


2.2.9 Management Measure 2H
Revegetation of Disturbed Areas

Management Measure

Reduce erosion and prevent sedimentation by rapid revegetation of areas disturbed by timber operations.

1. Revegetate disturbed areas (using seeding or planting) promptly after completion of earth-disturbing activity. Local growing conditions will dictate the timing for establishment of vegetative cover.

2. Use mixes of species and treatments developed and tailored for successful vegetation establishment for the region or area.

3. Concentrate revegetation efforts initially on priority areas such as disturbed areas in Streamside Management Areas (SMAs) or the steepest areas of disturbance near drainages.

2.2.9.1 Programs
California Department of Forestry and Fire Protection, State Nurseries. The Lewis A. Moran Reforestation Center in Yolo County and the Magalia Reforestation Center in Butte County make up the CDF Nursery System. The purpose of the reforestation centers is to provide native species seedlings for purchase by landowners for specific purposes, including reforestation, erosion control and watershed protection, windbreaks, Christmas trees, fuel wood, and approved research projects (http://www.fire.ca.gov/ResourceManagement/StateNurseries.asp).

2.2.9.2 Management Practices
A recently harvested or burned site is highly susceptible to erosion and should be protected immediately with a combination of new vegetation and more temporary controls to hold soil in place while the plantings take hold. The following are the major considerations for site revegetation:

- **Plant selection**: For revegetation efforts, native species should be selected as much as possible. Mixtures of seeds adapted to the site and annuals should be used to allow natural revegetation of native understory plants. Mixtures should include annual grasses (for quick growth), perennial grasses (for their better root systems), and legumes (for nitrogen). Especially preferable are species that have adequate soil-binding properties to control erosion. Seeds should be planted immediately after soil disturbance and a minimum of 6 weeks before periods of drought or frost. Fall seeding is best. Native woody plants planted in rows, cordons, or wattles are best on steep slopes.

- **Timing and methodology**: Seeding should be done as soon as is practical after soil disturbance, preferably before rain, to increase the chance of successful establishment. Seeding can be done by hand or vehicle or by hydraulic seeding from a pump truck or trailer. The seed should be evenly distributed to provide continuous cover. Soil should be mulched as needed to hold seeds in place, reduce the erosive impact of raindrops, and to preserve soil moisture. Fertilizer should be applied according to product labels and site-specific conditions. Fertilizers may be necessary in severely...
disturbed subsoils and cutbanks. Soils should be tested for nutrient content to ensure that the proper amount of fertilizer is applied.

- **Maintenance**: Once areas are seeded, they should be protected from grazing and vehicle damage until plants are well established. All seeded areas should be inspected for failures and repairs, and reseeding should be accomplished within the planting season. During non-growing seasons, temporary, interim surface stabilization methods should be used to control surface erosion. These can include mulching, spraying bare soils with tackifiers, or covering exposed areas with turf reinforcement mats.

### 2.2.9.3 Information Resources

- **Shasta County University of California Cooperative Extension, Recovering from Wildfire**: This publication covers emergency resources, how to assess damages, erosion control measures, road protection, salvage harvesting, and forest regeneration. There are tips on contracting with a registered professional forester and a short discussion of tax implications. There is also a section on cost-share programs and a list of contacts. Request a copy from Shasta County University of California Cooperative Extension, Forestry, 1851 Hartnell Avenue, Redding, CA 96002 (Telephone: 530-224-4902) or call the California Stewardship Helpline (Telephone: 1-800-PET-TREE).

- **Evaluating the Effectiveness of Postfire Rehabilitation Treatments** ([http://www.fs.fed.us/rm/pubs/rmrs_gtr63.html](http://www.fs.fed.us/rm/pubs/rmrs_gtr63.html)): A west-wide evaluation of the effectiveness of USDA Forest Service burned area emergency rehabilitation (BAER) treatment was undertaken as a joint project by USDA Forest Service Research and National Forest System staffs. This evaluation covers 470 fires and 321 BAER projects, from 1973 through 1998 in USDA Forest Service Regions 1 through 6. A literature review, interviews with key regional and USDA Forest Service BAER specialists, analysis of burned area reports, and review of USDA Forest Service and district monitoring reports were used in the evaluation.

- **California Exotic Pest Plant Council** ([http://www.caleppc.org](http://www.caleppc.org)): This council works to protect California wildlands from invasive plants through research, restoration, and education.

- **Alabama Forestry Commission, Revegetation/Stabilization** ([http://www.forestry.state.al.us/publication/bmp/Revegetations_Stabilization.pdf](http://www.forestry.state.al.us/publication/bmp/Revegetations_Stabilization.pdf)): This fact sheet, part of Alabama’s Best Management Practices for Forestry, provides guidance on techniques for revegetating disturbed areas.

- **USEPA, Watershed Academy Web: Forestry Best Management, Revegetation and Forest Regeneration** ([http://www.epa.gov/watertrain/forestry/subf1.htm](http://www.epa.gov/watertrain/forestry/subf1.htm)): This Web site serves as a forestry management module, with a series of interactive fact sheets on forestry management practices. The Web site includes diagrams, photographs, and review questions.

### 2.2.9.4 Case Study

*Restoring the land after the Pendola Fire.* After 2 days of the Pendola Fire in October 1999, dozens of landowners were burned out and over 11,000 acres of forestland destroyed. The community immediately turned to restoration, and within a few weeks, applications for CFIP (California Forest Improvement Program) cost-share funds began to come in. “We've been impressed with the aggressive manner in which people are reforesting their land,” noted Gary Brittner, who manages CFIP for the CDF for the Nevada-Yuba-Placer Unit. “This is high-quality land and reforestation after a fire is an important priority.” The effort to start the restoration work has involved landowners, registered professional foresters (RPFs), and
government agencies such as CDF. In addition to CFIP, other emergency funds such as CFIP (California Forestry Improvement Program) are available to landowners who have been affected by fire (http://ceres.ca.gov/foreststeward/html/pendola.html).

2.2.9.5 References

2.2.10 Management Measure 2I
Forest Chemical Management

Management Measure

Use chemicals when necessary for forest management in accordance with the following to reduce NPS pollution impacts due to the movement of forest chemicals offsite during and after application:

1. Ensure that applications are performed by skilled and licensed applicators according to the registered use, with special consideration given to impacts on nearby surface waters.

2. Carefully prescribe the type and amount of pesticides appropriate for the insect, fungus, or herbaceous species.

3. Prior to applications of pesticides and fertilizers, inspect the mixing and loading process and the calibration of equipment, and identify the appropriate weather conditions, the spray area, and buffer areas for surface waters and mixing and loading areas.

4. Establish and identify buffer areas for surface waters to protect beneficial uses. (This is especially important for aerial applications.)

5. Immediately report accidental spills of pesticides or fertilizers into surface waters to the California Office of Emergency Services (Cal/OES). Develop an effective spill contingency plan to contain spills.

2.2.10.1 Programs

California Department of Forestry and Fire Protection Pest Management Program. Forest pest specialists help protect the State's forest resources from native and introduced pests, conduct surveys and provide technical assistance to private forest landowners, and promote forest health on all forest lands (http://www.fire.ca.gov/ResourceManagement/ForestPest.asp).

California Department of Pesticide Regulation has programs to protect human health and the environment by regulating the sale and use of pesticides, and by fostering reduced-risk pest management in California (http://www.cdpr.ca.gov/).

2.2.10.2 Management Practices

Pesticides and fertilizers are occasionally used in forestry to reduce mortality of desired tree species and improve forest production. Because pesticides can be toxic if misused, they must be mixed, transported, loaded, and applied correctly (according to label instructions) to prevent potential NPS pollution. Fertilizers can also be toxic or can shift the ecosystem’s energy dynamics when used improperly, so it is important that they also be handled and applied in accordance with instructions on the label (USEPA, 2002).
Methods of chemical application: Generally, chemicals are applied by hand, from an airplane or helicopter (aerial spray), or mechanically. When forest chemicals are applied mechanically, it is most common to use a vehicle-mounted boom sprayer. The cost of chemical management depends on the method of application. Hand application costs approximately $100 per acre, while aerial application is less expensive at $55 to $70 per acre.

Using slow-release fertilizers when possible can reduce adverse impacts on the environment. This practice reduces potential nutrient leaching to ground water and it increases the availability of nutrients for plant uptake. Fertilizers should be applied during maximum plant uptake periods to minimize leaching. Fertilizers and herbicides should not be used in streams or Streamside Management Areas. If designed properly, forested buffer areas around watercourses can effectively reduce adverse effects on water quality from fertilizers (Megahan, 1980).

Riekerk and others (1989) found that the greatest risk to water quality from pesticide application in forestry operations occurred from aerial application because of drift, wash-off, and erosion processes. They found that aerial applications of herbicides resulted in surface runoff concentrations roughly 3.5 times greater than those for application on the ground. Therefore, where possible, aerial application of pesticides should be avoided. Alternatively, tree injection or hand application of herbicides should be used. Research results suggest that tree injection application methods, although labor intensive, are the least hazardous for water pollution (Riekerk et al., 1989).

When aerial spray applications are used, drift or accidental application of chemicals directly to surface waters should be avoided. Appropriate buffer widths should be determined by considering the altitude of application, weather conditions, and drop size distribution. Careful and precise marking of application areas for aerial applications helps avoid accidental contamination of open waters (USEPA, 2002).

Pesticides and fertilizers should be applied only during favorable atmospheric conditions. Pesticides should not be applied when wind conditions increase the likelihood of significant drift. It is also best to avoid pesticide application when temperatures are high or relative humidity is low because these conditions influence the rate of evaporation and enhance losses of volatile pesticides.

Following the label: Pesticide users need to abide by the current pesticide label, which could specify the following: whether users be trained and certified in the proper use of the pesticide; allowable use rates; safe handling, storage, and disposal requirements; and whether the pesticide may be used only under the provisions of an approved State Pesticide Management Plan.

Spill prevention: Areas where mixing, loading, and equipment cleaning occur should be located where pesticide residues cannot enter streams or other water bodies. Pesticide wastes and containers should be disposed of according to State and federal laws and precautions should be taken to prevent leaks and spills.

Integrated Pest Management: Ideally, the use of pesticides should be considered as only one part of an overall program to control pest problems. Integrated Pest Management (IPM) strategies have been developed to control forest pests without total reliance on chemical pesticides. The IPM approach uses all available techniques, including both chemical and nonchemical methods. An extensive knowledge of both the pest and the ecology of the affected environment is necessary for IPM to be effective.
2.2.10.3 Information Resources

- **Tree Notes** ([http://ceres.ca.gov/foreststeward/html/treenotes.html](http://ceres.ca.gov/foreststeward/html/treenotes.html)): Tree Notes is a series of short papers produced by the California Department of Forestry and Fire Protection to provide information on various pests and threats to forests. These resources are available from the local forester at any CDF Unit or call or write Jesse Rios, Forest Pest Specialist, P.O. Box 944246, Sacramento, CA 94244 (Telephone: 916-653-9476).

- **Pest Management In Perspective** ([http://ceres.ca.gov/foreststeward/html/pest.html](http://ceres.ca.gov/foreststeward/html/pest.html)): This is an article about pest management in forests.


- **USDA Forest Service, Pacific Southwest Region, Forest Health Protection (FHP), Forest Pests** ([http://www.fs.fed.us/r5/spf/about/fhp_forest_pests.htm](http://www.fs.fed.us/r5/spf/about/fhp_forest_pests.htm)): FHP is responsible for protecting, monitoring, and reporting on the health of all forest lands in the Pacific Southwest Region. FHP provides assistance in pest and pathogen identification.

- **University of California Statewide Integrated Pest Management Program (UC IPM)** ([http://www.ipm.ucdavis.edu/](http://www.ipm.ucdavis.edu/)): UC IPM develops and promotes the use of integrated, ecologically sound pest management programs in California. UC IPM's mission is to reduce the pesticide load in the environment and develop pest control programs that are economically, environmentally, and socially acceptable.

- **Spray Drift Task Force** ([http://www.agdrift.com/](http://www.agdrift.com/)): The Spray Drift Task Force, in collaboration with USEPA and USDA, co-developed AgDRIFT, a new model, to provide estimates of spray drift deposition under different pesticide application and meteorological conditions.

- **USDA Forest Service Cramer-Barry-Grim (FSCBG)** ([http://www.fs.fed.us/foresthealth/technology](http://www.fs.fed.us/foresthealth/technology)): The FSCBG spray dispersion model analyzes data on aircraft, meteorology, pesticides, and target areas to predict deposition and drift. A personal computer version of the model is available. It combines and implements mathematical models to assist forest managers in planning and implementing aerial spray operations.

- **USEPA, Watershed Academy Web: Forestry Best Management, Forest Chemicals.** ([http://www.epa.gov/watertrain/forestry/subh1.htm](http://www.epa.gov/watertrain/forestry/subh1.htm)): This Web site serves as a forestry management module, with a series of interactive fact sheets on forestry management practices. The Web site includes diagrams, photographs, and review questions.


2.2.10.4 Case Study

*Forest Chemicals. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats.* A nitrogen loss study cited in Norris and others (1991), compared nitrogen loss from a watershed treated with 224 kilograms (kg) urea-nitrogen per hectare with nitrogen loss from an untreated watershed. The study demonstrated that the loss of nitrogen from the fertilized watershed was 28.02 kg/hectare whereas the loss of nitrogen from the unfertilized watershed was only 2.15 kg/hectare.
Norris and others (1991) also compiled information from multiple studies that evaluated the peak concentrations of insecticides in soils, lakes, and streams. It was demonstrated that the concentration of insecticides in streams was significantly greater when the chemicals were applied without a buffer strip to protect the watercourse. In one study, when streams were unbuffered, the peak concentrations of applied malathion ranged from 0.037 to 0.042 milligrams per liter (mg/L). When buffers were provided, however, concentrations of malathion were reduced to levels that ranged from undetectable to 0.017 mg/L. In another experiment, the peak concentrations of carbaryl ranged from 0.000 to 0.0008 mg/L when watercourses were protected with a buffer, but they increased to 0.016 mg/L when watercourses were unbuffered.

### 2.2.10.5 References


2.2.11 Management Measure 2J
Wetlands Forest Management

Management Measure

Plan, operate, and manage normal, ongoing forestry activities (including harvesting, road design and construction, site preparation and regeneration, and chemical management) to adequately protect the aquatic functions of forested wetlands.

2.2.11.1 Programs

The California Wetlands Information System is a program of the California Resources Agency. This Wetlands Information System is designed to provide comprehensive wetlands information to the general public, the educational community, and government agencies. It is a compilation of public and private sector information, including maps, environmental documents, agency roles in wetlands management, restoration and mitigation activities, regulatory permitting, and wetland policies. It also includes a wetlands database and inventory (http://ceres.ca.gov/wetlands/).

California Department of Forestry and Fire Protection, Resource Management Program. Maintaining the sustainability of California’s natural resources is the goal of the CDF Resource Management Program. The Department achieves this goal by administering State and federal forestry assistance programs for landowners, demonstrating sound management practices on eight demonstration State forests, enforcing the California Forest Practice Act on all nonfederal timberlands, providing research and educational outreach to the public on forest pests such as Sudden Oak Death, and coordinating efforts for fuel reduction to reduce the risk of fire and improve the quality of California’s ecosystems. CDF’s mission emphasizes the management and protection of California's natural resources. The Resource Management Program is an integral part of that responsibility (http://www.fire.ca.gov/ResourceManagement/ResourceManagement.asp).

2.2.11.2 Management Practices

Forested wetlands provide beneficial ecosystem functions such as flood-flow alteration, sediment trapping, nutrient retention and removal, provision of important habitat for fish and wildlife, and provision of timber products. Wetlands in the continental United States have declined greatly in the past 40 years because of conversion to other land uses. In the past 200 years, California lost 91 percent of its original wetlands, mostly because of conversion to agriculture (Yuhas, 2003).

Practices that help maintain forested wetlands include the following:

- **Road building/maintenance**: Road construction and maintenance can adversely affect forested wetlands and should be avoided. Wetlands can fill with sediment runoff generated by road construction and the use of heavy equipment. Wetlands can also be degraded by improper road construction and ditching that alters wetland hydrology. In an effort to prevent these potential adverse effects, section 404 of the Clean Water Act (for more information about section 404, see http://www.epa.gov/owow/wetlands/regs/sec404.html) requires the use of appropriate management practices for road construction and maintenance in wetlands so that flow and circulation patterns are not impaired.
Temporary roads should be used in forested wetlands whenever possible. Temporary roads can be constructed to provide adequate crossroad drainage at all natural drainageways. Temporary drainage structures include culverts, bridges, and porous material such as corduroy or chunkwood. The root mat in any wetland that has grass mounds or other uneven vegetation should not be disturbed. Any temporary wetland crossing is enhanced by using a root or slash mat to provide additional support to the equipment.

Where construction of fill roads is necessary, a permeable fill material such as gravel or crushed rock should be used for at least the first layer of fill. The use of pervious materials helps maintain the natural flow regimes of subsurface water. Adequate cross drainage should be provided to maintain the natural surface and subsurface flow of the wetland.

- **Chemical use:** Wetland contamination can result from improper application or use of herbicides and fertilizers. Application of herbicides with toxicity to aquatic life should be avoided. Instead, herbicide formulations that are approved for use in or near water should be used where feasible and applicable. These herbicides should be applied by injection to individual stems to reduce losses to surface waters. Fertilizers should be applied when leaching will be minimal, and slow-release fertilizers should be chosen when possible. This practice reduces the potential of the nutrients to leach into ground water, and it increases the availability of nutrients for plant uptake.

- **Site preparation:** Site preparation techniques that degrade wetlands onsite or downstream should be avoided. Extensive site preparation on bottoms where frequent flooding occurs can cause excessive erosion and stream sedimentation. The degree of acceptable site preparation is governed by the amount and frequency of flooding, soil type, and species suitability and depends on the regeneration method used.

- **Permits:** Local, State, and federal agencies should be conferred with to identify applicable wetland regulations and obtain necessary permits to work in wetlands. Some forestry activities in wetlands are exempt from federal permitting requirements under section 404(f) of the Clean Water Act, while others are not.

- **Harvesting:** Harvest methods that cause less soil disturbance and compaction, such as cable logging or helicopter logging, should be considered. If using heavy equipment, low-ground-pressure, ultrawide, or high-flotation tires on logging trucks and skidders should be used to reduce soil compaction and erosion. Ground skidding harvesting operations should be suspended during wet periods in seasonally flooded wetlands.

### 2.2.11.3 Information Resources

- **Save The Bay, Protecting Local Wetlands: a Toolbox for Your Community.** ([http://www.savesfbay.org/Wetlands%20Handbook.html](http://www.savesfbay.org/Wetlands%20Handbook.html)): This document, produced by Save The Bay, in conjunction with the attorneys of Shute, Mihaly, and Weinberger, LLP, is designed to help government officials, resource agencies, nonprofit organizations, community activists, and landowners protect and restore their local wetlands throughout the San Francisco Bay-Delta Estuary.

- **USDA Forest Service, USDA NRCS, and USEPA, Forsted Wetlands Functions, Benefits, and Use of Best Management Practices** ([http://www.na.fs.fed.us/spfo/pubs/n_resource/wetlands/index.htm#Table%20of%20Contents](http://www.na.fs.fed.us/spfo/pubs/n_resource/wetlands/index.htm#Table%20of%20Contents)): The purpose of this publication is to present an array of management practices to protect the function of forested wetlands.

**Alabama Forestry Commission, Forested Wetland Management** ([http://www.forestry.state.al.us/publication/bmp/Forest_Wetland_Management.pdf](http://www.forestry.state.al.us/publication/bmp/Forest_Wetland_Management.pdf)): This fact sheet, part of Alabama’s Best Management Practices for Forestry, provides background information on the management of forested wetlands.

**USEPA, Watershed Academy Web: Forestry Best Management. Forest Wetland Management** ([http://www.epa.gov/watertrain/forestry/subc1.htm](http://www.epa.gov/watertrain/forestry/subc1.htm)): This Web site serves as a forestry management module, with a series of interactive fact sheets on forestry management practices. The Web site includes diagrams, photographs, and review questions.

**USEPA, Forested Swamps** ([http://www.epa.gov/owow/wetlands/types/swamp.html#forested](http://www.epa.gov/owow/wetlands/types/swamp.html#forested)): This Web site provides information on various types of forested wetlands.

### 2.2.11.4 References


2.2.12  Management Measure 2K
Postharvest Evaluation

Management Measure

Conduct post-operation evaluation of the effectiveness of the State’s forest practices requirements as implemented. The components of this are (a) implementation monitoring to determine whether the operation was conducted according to specifications, and (b) effectiveness monitoring after at least one winter period to determine whether the specified operation prevented or minimized discharges.

2.2.12.1  Programs

California Department of Forestry and Fire Protection, Resource Management Program. Maintaining the sustainability of California’s natural resources is the goal of the CDF Resource Management Program. The Department achieves this goal by administering State and federal forestry assistance programs for landowners, demonstrating sound management practices on eight demonstration State forests, enforcing the California Forest Practice Act on all nonfederal timberlands, providing research and educational outreach to the public on forest pests such as Sudden Oak Death, and coordinating efforts for fuel reduction to reduce the risk of fire and improve the quality of California’s ecosystems. CDF’s mission emphasizes the management and protection of California’s natural resources. The Resource Management Program is an integral part of that responsibility (http://www.fire.ca.gov/ResourceManagement/ResourceManagement.asp).

2.2.12.2  Management Practices

Timber harvest plan: Post-harvest evaluations of forest practices should be incorporated into the timber harvest plan (THP) if proposed timber operations have the potential to degrade drinking water supplies, lakes, or streams. Under the California Forest Practice Rules, the CDF may require a postharvest evaluation of the effectiveness of the mitigations and practices designed to protect the domestic water supply as a condition of THP approval. Problems to be identified include potential land failures, accelerated rate of road construction or harvesting within a watershed, or a concentration or intensity of harvesting activity near streams or springs (CDF, 2003). Where timber operations will be conducted within a Watercourse and Lake Protection Zone (WLPZ), the CDF may also require a postharvest evaluation of the effectiveness of the mitigation measures and practices designed to protect the water quality as a condition of THP approval.

Monitoring program: One should define the goals and objectives, or purpose, of the monitoring program. Detailed monitoring program objectives enable the designer of the program to define precisely which data will be gathered to meet the management goals and determine when management has failed or been successful. Postharvest evaluations can review the timber operator’s procedures for effectiveness and implementation monitoring or existing landowner monitoring programs, or use photographic monitoring techniques. A review of scientific and technical literature pertaining to water quality studies previously conducted in the region will help to determine whether existing data provide sufficient information to address the monitoring goals and to identify data gaps.

Implementation assessments: It is helpful to identify project constraints such as funding, staffing, equipment, time, and effort necessary to complete postharvest evaluations. The duration of monitoring...
and the geographic scale needed to achieve monitoring goals should be determined. Implementation assessments can be done on several scales. Site-specific assessments can be used to assess individual management practices or management measures, while watershed assessments can be used to look at the cumulative effects of implementing multiple management measures. Determination should be made as to which management measures should be evaluated, and a baseline should be established from which decisions can be made regarding the need for additional incentives for implementation of management measures.

A team of experts should be assembled to perform postharvest monitoring. Teams should include a state forester who is familiar with management practice standards for both implementation and effectiveness. Where possible, the survey team should be accompanied by the landowner on whose property the survey is being conducted, the logger who conducted the harvest, and the state forester who prepared the harvest plan, if applicable. Other experts could be specialists in fields such as watershed science, soil science, wildlife biology, hydrology, fishery management, or road engineering. Separate organizations might also be represented, such as environmental organizations or representatives of the timber industry.

If feasible, audits should be conducted soon after harvests are completed so that improvements can be made to management practices found to be inadequately implemented and to minimize the water quality impacts of those practices.

*Preharvest notification system:* A preharvest notification system should be established to assist in selecting an adequate and unbiased sampling population of harvest sites, to reduce the cost of site selection, and to help determine, prior to a site visit, that selected sites meet many of the selection criteria such as time since harvest and size of harvest. Harvest sites need to be chosen randomly. Stratification based on desired characteristics of sites is perfectly acceptable, but if this is done, sampling within the strata must be random to ensure the validity of results.

*QA/QC:* Quality assurance (QA) and quality control (QC) procedures should be implemented to ensure the accuracy of all analytical measurements made in postharvest evaluations. QA/QC procedures are cost-effective measures used to determine how to allocate project energies and resources toward improving the quality of research and the legal sufficiency of project results.

*Critical watersheds:* If the geographic extent of an audit includes a critical watershed, a separate statistically valid sample population should be created for the watershed and information from harvests within the watershed should not be grouped with information from other harvests. It is important to maintain separate information for watersheds that have been designated “critical” and to sample them separately if the information obtained is to be related to and useful for programs instituted to protect the watersheds.

### 2.2.12.3 Information Resources

- Numerous guidance documents have been developed, or are in development, to assist resource managers in developing and implementing monitoring programs that address all aspects of monitoring design. **Appendix A in Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls** presents a review of more than 40 monitoring guidance manuals for both point and NPS pollution. These guidance manuals discuss virtually every aspect of NPS pollution monitoring, including monitoring program design and objectives, sample types and sampling methods, chemical and physical water quality variables, biological monitoring, data analysis and management, and quality assurance and quality control (USEPA, 2002). This document is available through the National Service Center for Environmental Publications (Telephone: 800-490-9198).
Techniques for Tracking, Evaluating, and Reporting the Implementation of Nonpoint Source Control Measures—Forestry (http://www.epa.gov/owow/nps/forestry/index.html): Sampling design, approaches to conducting the evaluation, data analysis techniques, and ways to present evaluation results are described in this manual.

2.2.12.4 References

2.2.13 Management Measure 2L
Education/Outreach

Implement educational programs to provide greater understanding of watersheds, and to raise awareness and increase the use of applicable forestry management measures and practices where needed to control and prevent adverse impacts on surface and ground waters. Public education, outreach, and training programs should involve user groups and the community.

2.2.13.1 Programs
- The California Department Forestry and Fire Protection’s Fire and Environmental Education Program consists of school programs, fair exhibits, posters, flyers and thousands of other printed materials, radio and television spots, community meetings, one-on-one contact with wildland homeowners, and a Web site (http://www.fire.ca.gov/Education/Education.asp).
- The California Forest Stewardship Program is designed to encourage good stewardship of private forestland. This State government program provides technical and financial assistance to influence positive changes to forest land management, assists communities in solving common watershed problems, and helps landowners in a number of ways. For assistance, call the Forest Stewardship Helpline (Telephone: 1-800-PET-TREE; Web site: http://ceres.ca.gov/foreststeward/index.html).

2.2.13.2 Management Practices
Education and training are vital to effective management practice implementation. Educating and training loggers and landowners about the importance and use of management practices is an effective way to reduce water quality effects from forest operations because harvesters and landowners are responsible for forest harvesting and decisions concerning the management of much of the forested land in the nation.

These programs are based on the premise that it is important to teach forest ecology and silviculture to loggers because professional foresters supervise less than a third of all the acres harvested in the United States while loggers are involved in all of the harvests. Before these programs existed, few people employed in logging had training in forestry and silviculture, and the logger education programs are changing that situation. To accomplish its goal, logger training emphasizes five areas—safety and first aid, business management, harvesting operations, professionalism, and forest ecology and silviculture (USEPA, 2002).

2.2.13.3 Information Resources
- University of California Center for Forestry (http://www.cnr.berkeley.edu/forestry/information.html): The Center provides leadership in the development of basic scientific understanding of ecosystem processes, human interactions and value systems, and management and silvicultural practices that ensure the sustainability of forest land in California. Location: 145 Mulford Hall #3114, University of California, Berkeley, Berkeley, CA 94720-3114 (Telephone: 510-642-0095; Fax: 510-643-3490).
- **California Forest Stewardship Program** ([http://ceres.ca.gov/foreststeward/](http://ceres.ca.gov/foreststeward/)): The program is designed to encourage good stewardship of private forest land. The program provides technical and financial assistance to influence positive changes to forest land management, assists communities in solving common watershed problems, and helps landowners. It includes a Forest Stewardship Helpline (Telephone: 1-800-PET-TREE), a quarterly newsletter, programs that provide financial and technical assistance, demonstration projects, and a landowner curriculum. A calendar of natural resource events is updated regularly for information on conferences, workshops, and other programs for the public. Its Web site also provides contacts for technical assistance related to forest stewardship issues ([http://ceres.ca.gov/foreststeward/html/assistance.html](http://ceres.ca.gov/foreststeward/html/assistance.html)).

- **Forestry Institute for Teachers** ([http://www.forestryinstitute.org/](http://www.forestryinstitute.org/)): This program educates K-12 teachers about how ecosystems and their management affect the needs of both rural and urban citizens about water, wildlife, recreation, biological diversity, habitat protection, and consumer products derived from forests. Teachers who participate in the program are able to share their understanding of forest ecology and natural resource management principles and concepts with their students.

- **Humboldt State University College of Natural Resources and Sciences, Institute for Forest and Watershed Management** ([http://www.cnr.berkeley.edu/forestry/information.html](http://www.cnr.berkeley.edu/forestry/information.html)): The Institute is dedicated to the acquisition, compilation, dissemination, and application of knowledge about the sustainable management of ecological systems in Northern California (Telephone: 707-825-7350).

- **Northern California Society of American Foresters** ([http://www.humboldt.edu/~norcal/index.shtml](http://www.humboldt.edu/~norcal/index.shtml)): This organization provides forums for professional development and community outreach.

- **Southern California Society of American Foresters** ([http://www.ufei.calpoly.edu/socalsaf/](http://www.ufei.calpoly.edu/socalsaf/)): This organization provides forums for professional development and community outreach.

- **Registered Professional Forester Program** ([http://www.fire.ca.gov/CDFBOFDB/pdfs/Role%20of%20RPF_2002%20ygeditfinal.pdf](http://www.fire.ca.gov/CDFBOFDB/pdfs/Role%20of%20RPF_2002%20ygeditfinal.pdf)): A registered professional forester (RPF) is a person knowledgeable in a wide range of studies such as biology, ecology, entomology, geology, hydrology, dendrology, silviculture, engineering, business administration, forest economics, and other natural resource subjects. RPFs use their well-rounded education and experience to maintain the sustainability of forest resources like timber, forage, wildlife, water, and outdoor recreation to meet the needs of the people while protecting the biological integrity and quality of the forest environment.

### 2.2.13.4 Case Study

*Stewardship Education for Forest Landowners*: The Extension Forestry group of the California Forest Stewardship Program has developed a comprehensive curriculum on forest ecology and management. The target user for this curriculum is the nonindustrial forest landowner who owns parcels of forest land but who is not in the commercial timber production business for a livelihood. The topics covered in the curriculum are organized around the themes of “who, where, what, when, how, why, and how much” and cover virtually all aspects of land ownership and management ranging from mapping through taxation and investment analysis. Existing sources were used and new documentation prepared to round out the information base. In the summer of 2001 some of the materials were used at a 3-day workshop for landowners held in Redding, and the exposure was valuable for improving the presentations. More information about the forest landowner curriculum is available at [http://ceres.ca.gov/foreststeward/html/curriculum.html](http://ceres.ca.gov/foreststeward/html/curriculum.html).
2.2.13.5 References
2.3 Urban Areas

2.3.1 Introduction

With approximately 80 percent of the nation’s population living in coastal areas, controlling polluted runoff in urban areas is a challenge. Negative impacts of urbanization on coastal and estuarine waters are well documented in a number of sources, including California’s Clean Water Act section 305(b) and section 319 reports and the Nationwide Urban Runoff Program.

Major pollutants found in runoff from urban areas include sediment, nutrients, oxygen-demanding substances, road salts, heavy metals, petroleum hydrocarbons, pathogenic bacteria, viruses, trash, and plastics. Suspended sediments constitute the largest mass of pollutant loadings to receiving waters from urban areas. Construction is a major source of sediment erosion. Petroleum hydrocarbons result mostly from automobile sources. Nutrient and bacterial sources include garden fertilizers, leaves, grass clippings, pet wastes, and faulty septic tanks. As population densities increase, a corresponding increase occurs in pollutant loadings generated from human activities. Many of these pollutants enter surface waters via runoff without undergoing treatment.

The control of urban nonpoint source (NPS) pollution requires the use of two primary strategies: the prevention of pollutant loadings and the treatment of unavoidable loadings. California’s 15 urban management measures are organized to parallel the land use development process in order to address the prevention and treatment of NPS pollution loadings during all phases of urbanization; this strategy relies primarily on the watershed approach, which focuses on pollution prevention or source reduction practices. Pollution prevention and source reduction practices are favored over treatment practices because conducting education practices and incorporating pollution prevention practices into project planning and design activities are generally more effective, require less maintenance, and are more cost-effective in the long term than treatment strategies. Treatment strategies should be used only to address unavoidable loadings or where they are truly cost-effective.

The major opportunities to control NPS loadings occur during the following three stages of development: (1) the siting and design phase, (2) the construction phase, and (3) the post-development phase. Before development occurs, land in a watershed is available for a number of pollution prevention and treatment options, such as setbacks, buffers, or open space requirements, as well as wet ponds or constructed urban runoff wetlands that can provide treatment of the inevitable runoff and associated pollutants. In addition, siting requirements and restrictions and other land use ordinances, which can be highly effective, are more easily implemented during this period. After development occurs, these options may no longer be practicable or cost-effective. Management Measures 3.1A: Runoff from Developing Areas—Watershed Protection, 3.1B: Runoff from Developing Areas—Site Development, and 3.1C: Runoff from Developing Areas—New Development address the strategies and practices that can be used during the initial phase of the urbanization process.
The control of construction-related sediment loadings is critical to maintaining water quality. The implementation of proper erosion and sediment control practices during the construction stage can significantly reduce sediment loadings to surface waters. Management Measures 3.2A: Runoff from Construction Sites—Construction Site Erosion and Sediment Control and 3.2B: Runoff from Construction Sites—Construction Site Chemical Control address construction-related practices.

After development has occurred, lack of available land severely limits the implementation of cost-effective treatment options. Management Measure 3.3A: Runoff from Existing Development—Existing Development addresses strategies for reducing NPS pollution in already-developed areas. Management Measures 3.4A: Onsite Disposal Systems—New OSDSs and 3.4B Onsite Disposal Systems—Operating OSDSs describe practices to properly install innovative wastewater treatment systems and to reduce pollution from improperly designed or maintained septic tanks and treatment systems. Management Measures 3.5A: Transportation Development—Planning, Siting, and Developing Roads and Highways, 3.5B: Transportation Development—Bridges, 3.5C: Transportation Development—Construction Projects, 3.5D: Transportation Development—Chemical Control, 3.5E: Transportation Development—Operation and Maintenance, and 3.5F: Transportation Development—Road, Highway, and Bridge Runoff Systems address runoff from transportation infrastructure, including the activities involved in building and maintaining roads, highways, and bridges.

Finally, Management Measure 3.6A: Education/Outreach—Pollution Prevention/Education can be used to reduce the amount of pollutants generated or allowed to be exposed to runoff.

2.3.1.2 SWRCB and RWQCB’s NPDES Stormwater Program

The Urban NPS Program and Storm Water Programs are intricately linked in that both programs address aspects of urban runoff pollution. With respect to programs within the SWRCB and the RWQCBs, urban runoff is addressed primarily through the National Pollution Discharge Elimination System (NPDES) Permitting Program, although the SWRCB NPS Program will apply where the runoff is not regulated as a permitted point source discharge.

This permitted “point source” system of addressing urban runoff pollution is the result of the Water Quality Act of 1987, which amended the federal Clean Water Act to require NPDES permits for certain categories of storm water discharges. These “categories” of storm water discharges are described as follows:

Phase I of the Storm Water Program, defined in federal regulation in 1990, includes storm water discharges associated with “industrial” activities (as defined by the regulations), construction activities that disturb five acres of land or more, and discharges from municipal separate storm sewer systems (MS4s) serving populations of 100,000 people or more. Phase II of the Storm Water Program, defined in federal regulations in 1999, expanded the program to require NPDES permits for discharges from construction sites disturbing between one and five acres, from small MS4s that serve populations of less than 100,000, from some other governmental facilities, and from industrial facilities owned by small municipalities. The expansion of the Storm Water Program through Phase II has therefore expanded the applicability of the NPDES point source program to a greater number of communities, businesses, government facilities, and industries. The result is that most urban runoff in California is now subject to NPDES permits.

The expansion of the storm water NPDES program has resulted in applying NPDES requirements in areas where NPS was previously the sole regulatory program. In is important to understand that the NPDES Program supercedes the SWRCB or RWQCB NPS Program in the areas where there is overlap. NPDES permits require implementation of best management practices, which may or may not be similar to the...
management measures and management practices of the NPS Program. However, the SWRCB/RWQCB’s NPDES Program does not supercede the planning and land-use activities of other State agencies, such as the California Coastal Commission or the San Francisco Bay Conservation and Development Commission, which they are responsible for implementing under their own regulatory authorities.

The SWRCB/RWQCB NPDES permits are at least as stringent as the NPS Program and will ensure at least the same level of compliance and water quality protection as the NPS Program’s management measures provide. Further, the authority of the SWRCB/RWQCB NPS Program will still apply for land use activities not covered by NPDES permits and for municipalities, construction sites, and industries that fall outside of the Phase I and Phase II Storm Water Programs.
2.3.2 Management Measure 3.1A
Runoff from Developing Areas
Watershed Protection

Management Measure

Develop a watershed protection program to

1. Avoid conversion, to the extent practicable, of areas that are particularly susceptible to erosion and sediment loss;

2. Preserve areas that provide important water quality benefits and/or are necessary to maintain riparian and aquatic biota;

3. Protect to the extent practicable the natural integrity of water bodies and natural drainage systems associated with site development—including roads, highways, and bridges;

4. Limit increases of impervious surfaces; and

5. Provide education and outreach to address sources of NPS pollution.

2.3.2.1 Introduction

The intent of this management measure is to encourage land use and development planning on a watershed scale that takes into consideration sensitive areas that, by being protected, will maintain or improve water quality. Each element of the management measure addresses key issues that result in water quality degradation. Progress can be made when these issues are addressed holistically in a watershed-wide plan.

2.3.2.2 Programs

The California Department of Conservation, Division of Land Resource Protection, provides to landowners information on grants and financial assistance, mapping, and technical resources for protecting natural resources (http://www.consrv.ca.gov/DLRP/index.htm).

Through the Clean Water Act (CWA) section 401 certification program, Regional Water Quality Control Boards (RWQCBs) review projects that require a federal permit under CWA section 404 or that involve dredge or fill activities that may result in a discharge to waters of the United States. This is to ensure that the State's interests are protected on any federally permitted activity occurring in or adjacent to waters of the State. The process for applying for Water Quality Certification under CWA section 401 in California is described on the State Water Resources Control Board’s (SWRCB) Web site (http://www.swrcb.ca.gov/rwqcb2/certs.htm).

The California Department of Fish and Game (DFG) may regulate a project through the Streambed Alteration Agreement process. DFG issues Streambed Alteration Agreements when project activities have the potential to impact intermittent and perennial streams, rivers, or lakes (http://www.dfg.ca.gov/1600/index.shtml).
The Watershed Information Technical System (WITS), developed by the California Environmental Resources Evaluation System (CERES), is a program that provides the information and tools to support local watershed planning, restoration, monitoring, and education. CERES and WITS are programs of the California Resources Agency (http://ceres.ca.gov/watershed/).

California Environmental Quality Act: If CEQA compliance is required (if the project is not found to be exempt based on the current CEQA Guidelines), a local or State agency must act as the lead CEQA agency. More information about CEQA can be found at (http://ceres.ca.gov/ceqa/).

2.3.2.3 Management Practices

Part 1 of the management measure states that areas particularly susceptible to erosion and sediment loss, specifically areas with highly erodible soils or steep slopes, should be avoided when siting new developments. Arendt (1996) developed a process by which a development envelope could be defined based on factors such as soil type, slope, ecological significance, floodplain delineations, existing vegetation, and cultural/historical significance. On a larger scale, undeveloped areas can be ranked by overlaying data sets in a geographic information system (GIS) that describes factors such as those listed above to guide decisions regarding zoning classification.

The second part of the management measure deals with protecting areas that provide water quality benefits, including protection of riparian vegetation and wildlife. Wetlands and riparian areas can be protected by local governments through the implementation of buffer ordinances. In addition, landowners can choose to implement buffers and setbacks on their property and to protect wetlands and other ecologically sensitive areas from development. To formalize this process of protecting water resources, a variety of conservation mechanisms can be used, such as easements, deed restrictions, and covenants. Developers should be encouraged to protect water resources as a selling point (aesthetic and ecological amenity).

The third part of the management measure deals with protecting the integrity of water resources from the effects of site development and infrastructure. This can be accomplished by establishing setbacks from natural drainage areas and using vegetated buffers to provide additional protection. In addition, culverts and crossings can be designed to minimize impacts on riparian areas and to enhance natural drainage rather than impede or overwhelm it. Finally, grading plans can be designed to minimize the adverse hydrologic impacts of clearing and the creation of impervious areas by dispersing drainage to multiple outlets so as not to overwhelm a single drainage feature.

The fourth part of the management measure proposes limiting increases of impervious surfaces. Developers can use innovative site and structure designs that reduce building footprints, decrease the amount of paved infrastructure, and provide for dispersed drainage and infiltration of runoff from impervious surfaces to reduce “effective impervious surface,” which can be defined as impervious surface that is connected to the storm water drainage system. The concept of effective impervious surface is important, because when runoff from these surfaces is directed to pervious areas rather than an impervious drainage system (i.e., curbs, gutters, street surfaces, storm drain pipes), it can infiltrate, evaporate, or be taken up by vegetation, thereby reducing the total volume of runoff leaving a site.

The fifth part of the management measure deals with education and outreach regarding NPS pollution. There are abundant opportunities to involve the public in NPS pollution management, including distributing educational materials, holding training sessions and workshops, involving the public in water resource-specific activities such as cleanups and festivals, and encouraging stakeholder involvement in water resource-related decisions via public hearings and meetings. These activities can be focused on high-priority water bodies, groups who contribute to pollution (e.g., lawn care professionals, homeowners
with yards, pet owners), or specific demographic groups (e.g., Spanish-speaking populations, school children).

### 2.3.2.4 Information Resources

**Data for Watershed Evaluations and Determination of Site Characteristics**

- **Natural Resources Conservation Service Soil Maps** ([http://soils.usda.gov/soil_survey/pub_sur/ca.htm](http://soils.usda.gov/soil_survey/pub_sur/ca.htm)): Soil maps and electronic data available from the Natural Resources Conservation Service can be used to identify areas with highly erodible soils, and topographic maps and data can be purchased from the U.S. Geological Survey and used to identify steep slopes. To view a list of available soil surveys and to obtain soil maps, contact the State Conservationist or access the Soil Survey Request Form.

- **U.S. Fish and Wildlife Service, Pacific Region Field Offices** ([http://pacific.fws.gov/ecoservices](http://pacific.fws.gov/ecoservices) for Ecological Services staff contact information): Critical Habitat Areas for endangered species can be identified with the assistance of the Fish and Wildlife Service Pacific Region Field Offices in Yreka, Arcata, Red Bluff, Sacramento, Barstow, and Ventura.

- **The California Office of Historic Preservation** ([http://ohp.parks.ca.gov/](http://ohp.parks.ca.gov/)): The Office of Historic Preservation can provide guidance on identifying and conserving cultural or historical resources and meeting the requirements of CEQA, the National Environmental Policy Act (NEPA), and the National Historic Preservation Act (NHPA) regulations.

**Land and Water Resource Conservation Options**

- **Stormwater Manager’s Resource Center** ([http://www.stormwatercenter.net/](http://www.stormwatercenter.net/)): The Stormwater Manager’s Resource Center provides resources for those involved in local storm water management. These resources include a monitoring/assessment section that details environmental indicators, methods, factors to consider in an assessment, and assessment tools and models. The Web site also has articles about land conservation, open space ordinances, and a fact sheet on conservation easements.

- **Nonpoint Education for Municipal Officials (NEMO)** ([http://nemo.uconn.edu/](http://nemo.uconn.edu/)): NEMO offers guidance, research studies, data, and land use planning tools to help local officials make land use decisions that will protect natural resources.

- **The National Management Measures to Control Nonpoint Source Pollution from Urban Areas—Draft** ([http://www.epa.gov/owow/nps/urbanmm](http://www.epa.gov/owow/nps/urbanmm)): This guidance manual from USEPA has a review of the various options available for land and water resource conservation (pages 4-5) (USEPA, 2002).

- Nonprofit conservation organizations: Information about land and water resource conservation for landowners is available from several nonprofit organizations, including the [Land Trust Alliance](http://www.lta.org/), [The Conservation Fund](http://www.conservationfund.org/), and the Natural Lands Trust ([http://www.natlands.org/](http://www.natlands.org/)).

- **Wildlife Reserves and Corridors in the Urban Environment: A Guide to Ecological Landscape Planning and Resource Conservation** ([http://users.erols.com/urbanwildlife/bookstor.htm](http://users.erols.com/urbanwildlife/bookstor.htm)): This book by Lowell Adams and Louise Dove reviews the knowledge base regarding wildlife habitat reserves and corridors in urban and urbanizing areas and provides guidelines and approaches to
ecological landscape planning and wildlife conservation in such areas. It can be purchased from the Urban Wildlife Resources Bookstore at the Web site listed above.

- **Growing Greener: Putting Conservation into Local Codes** ([http://www.natlands.org/pdfFiles/growinggreener.pdf](http://www.natlands.org/pdfFiles/growinggreener.pdf)): Growing Greener is a statewide community planning initiative designed to help communities use the development regulation process to their advantage to protect interconnected networks of greenways and permanent open space. The booklet can be downloaded as a PDF file at the Web site listed above.

- **Smart Growth Network** ([http://www.smartgrowth.org/](http://www.smartgrowth.org/)): The Smart Growth Network is a nationwide effort coordinated by USEPA’s Urban and Economic Development Division. USEPA is working through cooperative partnerships with a diverse network of organizations to encourage development that better serves the economic, environmental, and social needs of communities. The network provides a forum for information-sharing, education, tool development and application, and collaboration on smart growth issues. Smart growth approaches focus on flexible zoning, preventive planning, intelligent management of natural resources and water quality, and implementation of treatment and control technologies at multiple scales from development sites to watershed planning.


- **Green Infrastructure Web site** ([http://www.greeninfrastructure.net/](http://www.greeninfrastructure.net/)): The concept of creating and maintaining an interconnected network of protected land and water is called Green Infrastructure. Green Infrastructure supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to health and quality of life. This Web site, developed by The Conservation Fund with support from USDA Cooperative Forestry, contains information to aid in implementing a comprehensive conservation program and includes resources such as searchable profiles, training information, events, and references databases.

### Buffer Resources

- **Model Ordinances to Protect Local Resources Web site** ([http://www.epa.gov/owow/nps/ordinance](http://www.epa.gov/owow/nps/ordinance)): USEPA published this Web site to provide model ordinance language and examples of ordinances that have been implemented by municipalities across the country.

- **Ordinance on Riparian Habitat Areas, City of Napa, California** ([http://www.stormwatercenter.net/Model Ordinances/napa_buffer_ordinance.htm](http://www.stormwatercenter.net/Model Ordinances/napa_buffer_ordinance.htm)): The City of Napa has implemented an ordinance to protect riparian areas that can be used as an example by other California municipalities.

- **Buffer Strips: Common Sense Conservation** ([http://www.nrcs.usda.gov/feature/buffers/](http://www.nrcs.usda.gov/feature/buffers/)): This USDA NRCS Web site features information on buffers including background information about the USDA NRCS buffer initiative and the benefits of buffers, technical information for implementing buffers, contacts that can provide assistance with buffer establishment, and examples of successful buffer implementation. A list of contacts can be found at this site as well. California-specific information about buffers can be found at [http://www.ca.nrcs.usda.gov/programs/buffer.html](http://www.ca.nrcs.usda.gov/programs/buffer.html).
Vegetated Stream Riparian Zones: Their Effects on Stream Nutrients, Sediments, and Toxic Substances (http://www.serc.si.edu/SERC_web_html/pub_ripzone.htm): This Web site presents an annotated and indexed bibliography of buffer strip literature.

Impervious Area Reduction/Innovative Site Designs

- The Center for Watershed Protection (http://www.cwp.org/): This nonprofit organization has produced several publications and other technical resources to help planners implement better site design techniques to reduce storm water from impervious surfaces. Specifically, the Rapid Watershed Planning Handbook, published in 1998, describes techniques that communities can use to more effectively protect and restore water resources.

- The Low Impact Development Center Web site (http://www.lowimpactdevelopment.org/): This nonprofit organization’s Web site provides technical references for implementing low impact development techniques and has case studies of sites where these practices have been successfully implemented.

2.3.2.5 References


2.3.3 Management Measure 3.1B
Runoff from Developing Areas
Site Development

**Management Measure**

Plan, design, and develop sites to

1. Protect areas that provide important water quality benefits necessary to main riparian and aquatic biota, and/or are particularly susceptible to erosion and sediment loss;

2. Limit increases of impervious areas;

3. Limit land disturbance activities such as clearing and grading, and cut-and-fill to reduce erosion and sediment loss; and

4. Limit disturbance of natural drainage features and vegetation.

**2.3.3.1 Programs**

Through the Clean Water Act (CWA) section 401 certification program, RWQCBs review projects that require a federal permit under CWA section 404 or that involve dredge or fill activities that may result in a discharge to waters of the United States. This is to ensure that the State's interests are protected on any federally permitted activity occurring in or adjacent to waters of the State. The process for applying for Water Quality Certification under CWA section 401 in California is described on the SWRCB Web site (http://www.swrcb.ca.gov/rwqcb2/certs.htm).

The California Department of Fish and Game (DFG) may regulate a project through the Streambed Alteration Agreement process. DFG issues Streambed Alteration Agreements when project activities have the potential to impact intermittent and perennial streams, rivers, or lakes. More information about this program can be found at DFG’s Web site (http://www.dfg.ca.gov/1600/index.shtml).

California Environmental Quality Act: If CEQA compliance is required (if the project is not found to be exempt based on the current CEQA Guidelines), a local or State agency must act as the lead CEQA agency. More information about CEQA can be found at http://ceres.ca.gov-ceQA/.

**2.3.3.2 Management Practices**

Development sites should be evaluated to identify areas that are less suitable for development (i.e., steep slopes, erodible soils, wetlands, land within the 100-year floodplain, and historically or culturally significant areas. Building footprints and infrastructure should be located away from these areas where feasible. Local governments can enact ordinances to protect specific resources such as wetlands or riparian areas, and landowners can be encouraged to voluntarily practice conservation of ecologically significant areas.

Traditional post-World War II development patterns dictate wide streets, large setbacks from the street (resulting in long driveways), and sidewalks on both sides of the street. These infrastructure patterns create an excess of impervious surface, which generates more runoff than would undeveloped land, grass,
and other landscaped areas. Exacerbating this problem is the fact that most modern developments have curb and gutter systems to efficiently collect and rapidly convey this runoff to natural drainage systems, which can overwhelm the receiving water body and result in flooding and water quality degradation.

In recent years, techniques have been developed to redesign traditional subdivisions and commercial properties to reduce the amount of land converted to impervious surfaces. These techniques have many names—including cluster development, open space design, better site design, and low impact development—but a common feature of all of them is to reduce the amount of impervious surfaces created on a particular site. This might involve any of the following practices:

- Designing streets to be narrower
- Placing sidewalks on only one side of the street
- Providing pervious areas for on-street parking
- Redesigning the layout of buildings to reduce street length and preserve open space
- Reducing setbacks for houses
- Reducing parking lot sizes to reflect actual usage
- Promoting shared parking among nearby businesses with different peak demands for parking (e.g., churches and retail businesses)
- Disconnecting impervious surfaces through creative grading plans and distributed infiltration areas

These techniques, among others, can be used as appropriate to reduce the impact of an individual development site on receiving waters. Municipalities can require that these types of practices be implemented through an ordinance that provides modified, environmentally friendly standards for infrastructure dimensions and layouts. In addition, these practices can be encouraged through storm water credits or density credits provided as incentives to developers.

To limit land disturbance activities, developers and construction site contractors can practice site fingerprinting, which is a technique that reduces the amount of land disturbed on a development site to that which will be built upon. Site fingerprinting entails flagging off areas where vegetation is to be preserved so that heavy equipment will not be driven over those areas and so that stockpiles will be placed elsewhere. Signage and other training/education materials for construction site workers are essential to ensure that the protected areas remain undisturbed.

2.3.3.3 Information Resources

- **California New Development and Redevelopment Handbook** ([http://www.cabmphandbooks.org/](http://www.cabmphandbooks.org/)): Section 2 of this manual contains information about storm water quality planning for new development and redevelopment, including permit requirements, planning principles, techniques for reducing runoff and managing impervious areas, source controls, runoff treatment controls, modifying development layouts, conducting a site evaluation, and selecting management practices. Section 3 discusses how site layouts should be designed to reduce water quality impacts.
• **National Menu of Best Management Practices for Storm Water Phase II, Post-Construction Storm Water Management in New Development and Redevelopment Fact Sheets** ([http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm)): USEPA’s guidance for small NPDES-regulated municipalities details several site design practices to reduce the amount of storm water generated on a development site and to disconnect impervious surfaces from the municipal separate storm sewer system. Especially useful for this management measure are the fact sheets listed under “On-lot Treatment” and “Better Site Design.”

• **Center for Watershed Protection Resources** ([http://www.cwp.org/](http://www.cwp.org/)): The Consensus Agreement on Model Development Principles to Protect Our Streams, Lakes, and Wetlands outlines the series of 22 nationally endorsed principles developed by the Site Planning Roundtable, a national cross section of diverse planning, environmental, home builder, fire, safety, public works, and local government personnel, and details basic rationale for their implementation. Also, Better Site Design: A Handbook for Changing Development Rules in Your Community outlines 22 guidelines for better developments and provides detailed rationale for each principle. Better Site Design also examines current practices in local communities, details the economic and environmental benefits of better site designs, and presents case studies from across the country. The Center also provides technical information about reducing impervious surfaces in new developments.

• **Growing Greener: Putting Conservation into Local Codes** ([http://www.natlands.org/pdffiles/growinggreener.pdf](http://www.natlands.org/pdffiles/growinggreener.pdf)): In 1997 Randall Arendt of the Natural Lands Trust, Inc., published Growing Greener, which is a statewide community planning initiative designed to help communities use the development regulation process to their advantage to protect interconnected networks of greenways and permanent open space.

• **Low Impact Development Center** ([http://www.lowimpactdevelopment.org/](http://www.lowimpactdevelopment.org/)): This nonprofit organization’s Web site has technical resources and case studies that illustrate successful implementation of low impact development techniques.

• **Low-Impact Development Design Strategies: An Integrated Design Approach** (EPA-841-B-00-003) and **Low-Impact Development Hydrologic Analysis** (EPA-841-B-00-002), both developed by the Prince George’s County, Maryland, Department of Environmental Resources, discuss site planning, hydrology, distributed integrated management practice technologies, erosion and sediment control, and public outreach techniques that can reduce storm water runoff from new and existing developments. Both publications can be ordered free of charge through USEPA’s National Service Center for Environmental Publications at [http://www.epa.gov/ncepihom/index.htm](http://www.epa.gov/ncepihom/index.htm).

• **Residential Streets**, prepared by the American Society of Civil Engineers, the National Association of Home Builders, and the Urban Land Institute, discusses design considerations for residential streets based on their function and their place in the neighborhood. The publication presents guidance on street widths, speeds, pavement types, streetscapes, rights-of-way, intersections, and drainage systems. It can be ordered online at [http://www.amazon.com/](http://www.amazon.com/) or other online booksellers.

• **Traditional Neighborhood Development—Street Design Guidelines** ([http://www.ite.org/bookstore/](http://www.ite.org/bookstore/)): The Institute of Transportation Engineers (ITE) published this manual, which details traditional neighborhood designs that foster pedestrian movement in place of automobile traffic are discussed and design concepts such as on-street parking, street width, and sight distances are presented. The publication also includes a practical discussion of the time needed for community acceptance and travel behavior changes. ITE also published Guidelines for Residential Subdivision Street Design (1993), which presents a discussion of the overall design of a residential subdivision with respect to the adequacy of vehicular and pedestrian
access, minimizing excessive vehicular travel, and reducing reliance on extensive traffic regulations. It also includes design considerations for local and collector streets and intersections, including such topics as terrain classifications, rights-of-way, pavements, curb types, and cul-de-sacs. These publications are available through the ITE’s online bookstore.

- **Street Design Guidelines for Healthy Neighborhoods** ([http://www.lgc.org/bookstore/land_use/publications/healthystreets.html](http://www.lgc.org/bookstore/land_use/publications/healthystreets.html)): This is a guidebook intended to help communities implement designs for streets that are safe, efficient, and aesthetically pleasing for both people and cars. This publication can be purchased from the Local Government Commission’s Center for Livable Communities Web site.

- **Reduced Width Street Standards Database** ([http://www.sonic.net/abcaia/narrow.htm](http://www.sonic.net/abcaia/narrow.htm)): The Congress for the New Urbanism has compiled a database of jurisdictions across the country that have adopted reduced width street standards. The database also includes resources related to neighborhood design and transportation.
2.3.4 Management Measure 3.1C
Runoff from Developing Areas
New Development

Management Measure
1. By design or performance:

After construction has been completed and the site is permanently stabilized, reduce the average annual total suspended solids (TSS) loadings by 80 percent (for the purposes of this measure, an 80 percent TSS reduction is to be determined on an average annual basis); or

Reduce the post-development loadings of TSS so that the average annual TSS loadings are no greater than pre-development loadings.

2. To the extent practicable, maintain post-development peak runoff rate and average volume at levels that are similar to pre-development levels.

The first part of this management measure addresses increased pollutant loads associated with developed lands. The second part of this management measure addresses the hydrologic alterations resulting from development that affects runoff volume and timing. Developers can use innovative site planning techniques or incorporate runoff management practices to reduce the hydrologic impact of development on receiving waters.

2.3.4.1 Programs
NPDES Storm Water Program. Most urban runoff is regulated under the NPDES permitting program as point source discharges from municipally owned or operated separate storm sewer systems (MS4s). This program has requirements distinct from those of the NPS program, although the same set of management practices is appropriate for controlling pollutants from both storm water and nonpoint sources. The specific requirements for owners and operators of MS4s depend on the municipality's or public entity's population size and water quality concerns. More information about the requirements can be found at California's Storm Water Program Web site (http://www.swrcb.ca.gov/stormwtr/).

2.3.4.2 Management Practices
In urban areas that do not meet the criteria to be covered under the NPDES storm water regulation, the NPS program requires that owners of new developments implement management practices to meet the requirements of the management measure described above. There are two parts to the requirement: first, runoff quality must be addressed by implementing treatment controls that remove at least 80 percent of the average annual TSS loadings in runoff. TSS is used as a measure of pollutant removal effectiveness because it is a common pollutant in urban runoff and is often associated with other pollutants such as nutrients and heavy metals. The second part of the management measure directs developers to implement practices to control the timing and volume of runoff leaving the site such that it mimics the hydrology of the site before development. The adverse impacts of increased hydraulic loadings to urban streams are well documented and include channel widening, instream and riparian habitat loss, increased pollutant loads, temperature impacts, and increased erosion of streambanks and streambeds, to name a few.
The NPS management measures do not specify a single method that should be used to achieve this level of pollutant removal, which allows developers flexibility in meeting both the 80 percent TSS removal and pre-development hydrology criteria. The types of technologies that can be used to achieve both criteria include detention ponds/vaults, retention ponds and wetlands, infiltration practices, filtration practices, open channel practices, and various proprietary practices, as described in the following:

- **Temporary detention ponds or vaults** that hold runoff and release it slowly but completely after a 72-hour or shorter period.

- **Retention pond or wetlands** in which a permanent pool of water is maintained and runoff is slowly released over time. Retention practices, by allowing water to stand for a longer period of time, achieve greater pollutant removal through settling and allow for biological uptake using wetland vegetation.

- **Infiltration practices**, such as basins, trenches, and French drains, collect runoff and convey it through a porous matrix into the ground water.

- **Filtration practices**, such as sand or organic filters and bioretention practices, act similarly to infiltration practices but are designed to achieve greater pollutant removal and have limited hydraulic loading capacities.

- **Open channel practices**, such as grassed swales, are commonly and effectively used to collect, convey, and infiltrate runoff, but they are not intended to drain large areas of impervious surfaces and therefore are typically implemented in combination with other practices.

- **Proprietary practices** that are typically installed underground use mechanisms such as settling, absorption, and microfiltration as well as other mechanisms such as centrifugal force and gross filtration to remove solids and floatable debris.

### 2.3.4.3 Information Resources

- **California New Development and Redevelopment Handbook** ([http://www.cabmphandbooks.org/](http://www.cabmphandbooks.org/)): Section 2 of this manual contains information about storm water quality planning for new development and redevelopment, including permit requirements, planning principles, techniques for reducing runoff and managing impervious areas, source controls, runoff treatment controls, modifying development layouts, conducting a site evaluation, and selecting management practices. Section 3 discusses how site layouts should be designed to reduce water quality impacts.

- **Model Urban Runoff Program Appendix 4T: Post-Construction Controls** ([http://www.coastal.ca.gov/la/docs/murp/4t.pdf](http://www.coastal.ca.gov/la/docs/murp/4t.pdf)): The appendix to this manual contains a section on treatment controls that describes rooftop treatment systems, vegetated filter strips, vegetated swales, infiltration basins and trenches, detention ponds, retention ponds, constructed wetlands, filtration practices, and oil/grit separators. It also includes a list of additional resources for more information.

- **USEPA, National Management Measures Guidance to Control Nonpoint Source Pollution from Urban Areas—Draft** ([http://www.epa.gov/owow/nps/urbanmm](http://www.epa.gov/owow/nps/urbanmm)): Management Measure 5 of this manual describes the different types of treatment controls, including design and maintenance considerations, cost, and effectiveness.

NPDES-regulated municipalities details numerous runoff treatment practices to reduce the volume of and pollutant concentrations in storm water from new development sites.

- **California Department of Transportation (Caltrans), Statewide Storm Water Quality Practice Guidelines**
  (http://www.dot.ca.gov/hq/env/stormwater/special/swmp_guidelines_5_03/section5.pdf): Section 5 of this manual describes treatment practices that Caltrans has approved (biofiltration swales and strips, infiltration basins, detention devices, traction sand traps, dry weather flow diversion, and linear radial device and inclined screens) and the process by which the practices are selected, sized, designed, and implemented to minimize environmental impact.

- **USEPA, Environmental Technology Verification (ETV) Web site**
  (http://www.epa.gov/etv): The ETV program Web site, sponsored by USEPA and the National Sanitation Foundation, develops testing protocols and verifies the performance of innovative technologies for environmental controls, including storm water treatment practices. It is a good source for determining the relative performance of new proprietary technologies.

- **Caltrans New Technology Report**
  (http://www.dot.ca.gov/hq/env/stormwater/annual_report/2003/annual_report/2003_new_technology_report.pdf): This report summarizes and standardizes information on new technologies, including the latest innovations in permanent storm water treatment and control and existing technologies currently in use. The report contains fact sheets describing progress in 121 existing full-scale and small-scale pilot studies for new technologies. The categories of practices being tested include adsorption/ion exchange, chemical treatment, disinfection, drain inlet inserts, detention basin outlet improvements, filters, filtration, infiltration trenches with alternative backfill, litter and debris removal, and sedimentation.

  (http://www.lacity.org/SAN/wpd/index.htm): This document provides background information on various storm water management practices, along with comprehensive selection matrices, cost information, and target pollutants for each management practice.

- **Los Angeles County Department of Public Works, Standard Urban Storm Water Mitigation Plan (SUSMP)**
  (http://www.ladpw.org/wmd/NPDES/SUSMP_MANUAL.pdf): As required by LA County’s Development Planning Model Program, the SUSMP was developed to guide builders, land developers, engineers, planners, and others in the selection of post-construction management practices. The document also provides guidance to assist in gaining municipal approval for urban storm water runoff mitigation plans prior to the issuance of building and grading permits.
2.3.5 Management Measure 3.2A
Runoff from Construction Sites
Construction Site Erosion and Sediment Control

Management Measure

1. Reduce erosion and, to the extent practicable, retain sediment on site during and after construction; and

2. Prepare and implement, prior to land disturbance, an effective, approved erosion and sediment control plan or similar administrative document that specifies erosion and sediment control provisions.

2.3.5.1 Programs
Discharges of pollutants from construction activities are for the most part regulated under the NPDES permitting program. Regulated entities include all construction sites with one or more acres of disturbed area. The SWRCB, Division of Water Quality, Storm Water Program Web site (http://www.swrcb.ca.gov/stormwtr/construction.html) provides information to permittees to help them meet the requirements of the NPDES regulations.

Discharges of pollutants from construction sites smaller than 1 acre typically are considered nonpoint sources but might also be regulated at the local level. Construction site operators should contact the municipal department for more information about local requirements, including air quality requirements for dust control.

2.3.5.2 Management Practices

Storm Water Pollution Prevention Plan

A storm water pollution prevention plan (SWPPP) describes in detail how a contractor or developer will reduce soil erosion and contain and treat runoff bearing eroded sediments and construction site chemicals. It normally includes the locations and type of pollutants present, as well as practices used on the site for soil stabilization, perimeter control, and runoff treatment, including vegetation practices, structural and nonstructural practices. It also details spill control measures, response actions, and a monitoring program. The SWPPP entails more than filing written documentation. It requires follow-through on the part of both the developer (for implementation) and regulator or permitting agency (for inspection and enforcement). This follow-through can include reviewing and modifying the SWPPP to account for unexpected events that occur after plans have been approved, and adapting to unforeseen conditions on the site. It must also include inspecting and assessing the effectiveness of implemented management practices on storm water quality. In some cases, practices will require maintenance or alternative or additional management practices.
Erosion Control Practices

Erosion control is the first step in reducing sediment pollution from construction sites. There are several opportunities for erosion control, beginning at the planning stages of construction. Clearing and grading should be scheduled during the dry season when storm water runoff is expected to be minimal. Construction should be undertaken in a phased schedule, in contrast to the traditional practice of grading a site or excavating it all at once. In phased construction, clearing, grading, and building take place at only one part of a site at a time, and new parts of the site are cleared only after the last part is stabilized with permanent erosion controls and revegetated.

Site fingerprinting is a technique that can be used to protect vegetation and reduce erosion. This practice limits clearing to areas that will be used for buildings, roads, and other infrastructure, leaving undisturbed areas that will be vegetated open space in the final plan. Areas that will remain undisturbed need to be marked off and construction equipment and stockpiles must be excluded to protect the existing vegetation and prevent compaction or erosion. The advantages of site fingerprinting are that natural areas are protected and fewer costs for landscaping are incurred. A disadvantage is that equipment will need to be maneuvered around these protected areas, possibly leading to increased labor hours.

The use of chemical additives to stabilize the soil is sometimes recommended to reduce erosion of exposed, unvegetated areas. Polyacrylamide (PAM) is a common polymer for controlling erosion and promoting infiltration on irrigated agricultural lands, and it has been recommended to reduce erosion on urban construction sites and disturbed areas. It decreases soil bulk density, absorbs water, and binds fine-grained soil particles. Caution should be used when applying PAM in ecologically sensitive areas because its toxicity to aquatic life is unknown. For more information about using PAM at construction sites, visit [http://www.epa.gov/ORD/WebPubs/nctuw/Roa-Espinosa.pdf](http://www.epa.gov/ORD/WebPubs/nctuw/Roa-Espinosa.pdf) (Roa-Espinosa et al., 2000). This paper provides a literature review and experimental results of PAM use at construction sites.

After clearing, grading, and building are complete, temporary and permanent erosion controls should be implemented, including seeding, mulching, sodding, and installing erosion control blankets:

- **Seeding** with native grasses can be used to establish permanent erosion control. There are several seeding techniques that can be used, including broadcast seeding, hydroseeding, and drill seeding. Broadcast seeding is the simplest method and involves scattering seeds by hand or mechanically. Hydroseeding involves spraying a slurry of seeds, fertilizer, tackifier, and water onto exposed soils. This method is more expensive but can be more effective at erosion control because the water and fertilizer additives promote fast growth and the tackifier provides immediate stabilization.

- **Mulching** of disturbed soils can be effective at reducing erosion. Materials used include tacked straw and wood chips and are often covered by erosion control blankets or netting. The mulch typically has a short useful life and is only a temporary measure. Mulching alone should be used when permanent seeding is not feasible, such as in arid or winter conditions when vegetative growth is slow or absent.

- **Using sod** permanently and immediately stabilizes an area with a thick vegetative cover and should be used in sensitive areas or where establishing permanent vegetation by seeding would be difficult.

- **Erosion control blankets** or **turf reinforcement mats** (TRMs) protect the soil from scouring due to runoff and can enhance vegetative growth. TRMs can raise the threshold of natural vegetation to

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withstand higher hydraulic forces on slopes and streambanks and in channels. They should be used in combination with seeding to achieve permanent results.

- **Wind erosion controls**, which include bales of hay, solid board fences, and snow fences, can be used to keep soil in place. Sprinkling with water can moisten the soil surface, but watering should be done in moderation to prevent a non-storm water discharge.

- Runoff can be intercepted above disturbed sites and conveyed to a permanent channel or storm drain. Conveyance systems may be *earth dikes*, *perimeter dikes/swales*, or *diversions*. A pipe slope drain or pipe drop structure is a temporary pipe placed from the top of a slope to the bottom of the slope to convey concentrated runoff down the slope without causing erosion.

- On long or steep, disturbed, man-made slopes, *benches, terraces, or ditches* can be constructed at regular intervals, or retaining walls can be erected, to intercept runoff, slow it down, and prevent it from becoming concentrated flow.

- *Linings* for urban runoff conveyance channels can be installed to prevent scouring. The first choice of lining should be grass or sod because it reduces runoff velocities and provides water quality benefits through filtration/infiltration. Also effective are turf reinforcement mats, riprap, concrete, and gabions.

- *Flow control practices* can be installed in channels to reduce runoff velocity. For example, check dams are small temporary dams constructed across a swale or channel and can be used to reduce the velocity of concentrated flow and, therefore, to reduce erosion in a swale or channel.

### Sediment Control Practices

The second step in preventing sediment pollution from construction sites is to install devices that trap or filter sediment from runoff. These can include sediment basins and traps, filter fabric fences, inlet protection devices, and stabilized construction entrances.

- **Sediment traps**: These are typically installed in a drainage way or other point of discharge from a disturbed area. They are small impoundments that allow some sediment to settle out of runoff water before it is drained through a rock dam. Temporary diversions in the form of berms or channels can be used to direct runoff to the sediment trap.

- **Sediment basins**: The use of sediment basins is a popular way to retain sediment generated at the site during construction and can be adapted to serve as runoff control after the site is stabilized. A perforated pipe riser (sometimes wrapped in filter fabric) connected to a drain pipe constricts flow and slowly releases impounded water from the bottom of the basin. A recent modification to the standard sediment basin design is the use of a floating skimmer, which slowly drains relatively clear water from the top of the basin. These structures require regular inspection and maintenance to ensure that they are not clogged with debris or sediment.

- **Filter fabric fence**: Filter fabric or silt fences can be used along the perimeter of the disturbed area to filter out sediment as runoff flows through the fabric. Such fences should be used only where there is sheet flow (no concentrated flow), and the maximum drainage area should be one-half acre or less per 100 feet of fence.


- **Storm drain inlet protection:** Sediment should be excluded from storm drains using inlet protection measures to trap sediment before it enters the storm sewer system. Common inlet protection measures include riprap wrapped in chicken wire, cinder blocks filled with gravel, straw wattles wrapped in filter fabric, drop-inlet bags, and other combinations of materials that filter runoff. Inspection and maintenance of these measures is essential to their effectiveness; failure to remove sediments and debris can result in reduced treatment of runoff and flooding due to clogging.

- **Stabilized construction entrances.** Construction entrances should be clearly designated and reinforced with gravel, corrugated metal sheets, or devices specially designed to clear tires of sediment and hold it for later cleanout. This practice of protecting construction entrances can minimize the loss of sediment associated with the equipment and traffic leaving the site.

### 2.3.5.3 Information Resources

- **California Storm Water Program Web site** ([http://www.swrcb.ca.gov/stormwtr/construction.html](http://www.swrcb.ca.gov/stormwtr/construction.html)): This site provides information to permittees to help them meet the requirements of the NPDES regulations. The site includes frequently asked questions, the construction general permit, forms, and tools for searching State databases of permits.

- **Storm Water Best Management Practice Handbook: Construction** ([http://www.cabmphandbooks.org/Construction.asp](http://www.cabmphandbooks.org/Construction.asp)): The Construction Handbook outlines waste management practices in a set of fact sheets that include erosion controls (scheduling, velocity dissipation devices, slope drains, streambank stabilization, polyacrylamide, preservation of existing vegetation, hydraulic mulch, hydroseeding, soil binders, straw mulch, geotextiles and mats, wood mulching, earth dikes, and drainage swales), sediment controls (silt fence, storm drain inlet protection, chemical treatment, sediment basins, sediment traps, check dams, fiber rolls, gravel bag berms, street sweeping and vacuuming, sandbag barriers, straw bale barriers, stabilized construction entrances and exits, stabilized construction roadways, entrance/outlet tire washing), and wind erosion control.

- **Erosion and Sediment Control Field Manual** ([http://store.abag.ca.gov/construction.asp](http://store.abag.ca.gov/construction.asp)): This manual from the San Francisco RWQCB describes management practices for construction site planning and management, erosion and sediment control, pollution prevention, and sampling guidelines. Descriptions of practices are concise and include full-color graphics and installation information including guidelines, timing, and limitations. The manual also includes the new Phase II regulations, the SWRCB’s sampling and monitoring guidelines, and long-term maintenance information. Also available are several erosion and sediment control videos (in English and Spanish), *Guidelines for Construction Projects*, and a *CD Training Kit* that includes a complete training kit for construction site planning and management for compliance with NPDES requirements, the 1999 version of the Erosion and Sediment Control Field Manual, and Guidelines for Construction Projects.

2.3.5.4 References


2.3.6 Management Measure 3.2B
Runoff from Construction Sites
Construction Site Chemical Control

Management Measure

1. Limit application, generation, and migration of toxic substances;

2. Ensure the proper storage and disposal of toxic materials;

3. Apply nutrients at rates necessary to establish and maintain vegetation without causing nutrient runoff to surface waters; and

4. Prepare and implement, prior to the use or storage of toxic materials on site, an effective, approved chemical control plan or similar administrative document that contains chemical control provisions (e.g., minimize use of toxic materials; ensure proper containment if toxic materials are to be used/stored on site).

2.3.6.1 Programs
Discharges of pollutants from construction activities are for the most part regulated under the NPDES permitting program. Regulated entities include all construction sites with 1 or more acres of disturbed area. The SWRCB Division of Water Quality, Storm Water Program Web site (http://www.swrcb.ca.gov/stormwtr/construction.htm) provides information to permittees to help them meet the requirements of the NPDES regulations. Discharges of pollutants from construction sites smaller than 1 acre typically are considered nonpoint sources, but may also be regulated at the local level.

The California Department of Pesticide Regulation regulates the storage and use of all pesticides. The Department’s Web site (http://www.cdpr.ca.gov/) contains links to information regarding laws and regulations; product use information; licensing and certification programs for applicators, dealers, and advisors; integrated pest management practices (see the School IPM link for health- and environment-conscious pest management practices); and other information related to pesticide use.

2.3.6.2 Management Practices
The practices associated with this management measure focus on properly using chemicals that might be spilled or transported in runoff, which means storing and using chemicals according to the instructions on the label. Users can help to ensure that chemicals will not become pollutants in runoff by providing a covered storage area with primary and secondary containment of chemicals and storage off the ground to prevent accidental spills or leaks. Care should be taken to not use chemicals during wet weather or high wind conditions. Also, less toxic alternatives should be considered.

Pesticides: The following practices should be used to reduce risks associated with pesticides or to reduce the amount of pesticides that come in contact with storm water:

- Follow all federal, State, and local regulations that apply to the use, handling, or disposal of pesticides.
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- Do not handle the materials any more than necessary.
- Store pesticides in a dry, covered area.
- Construct curbs or dikes to contain pesticides in case of spillage.
- Follow the recommended application rates and methods.
- Have equipment and absorbent materials available in areas where pesticides are stored and used in order to contain and clean up any spills that occur.

Petroleum products: The following management practices should be followed to reduce the risk of contamination associated with petroleum products:

- Store petroleum products and fuel for vehicles in covered areas with dikes in place to contain any spills.
- Immediately contain and clean up any spills with absorbent materials.
- Have equipment available in fuel storage areas and in vehicles to contain and clean up any spills that occur.

Solid wastes: State or local solid waste regulatory agencies or private firms should be consulted to ensure the proper disposal of contaminated soils that have been exposed to and still contain hazardous substances. Some landfills might accept contaminated soils, but they require laboratory tests first. The following steps should be taken to ensure proper storage and disposal of solid wastes:

- Designate a waste collection area onsite that does not receive a substantial amount of runoff from upland areas and does not drain directly to a water body.
- Ensure that containers have lids so they can be covered before periods of rain, and keep containers in a covered area whenever possible.
- Schedule waste collection to prevent the containers from overfilling.
- Clean up spills immediately. For hazardous materials, follow cleanup instructions on the package. Use an absorbent material such as sawdust or kitty litter to contain the spill.
- During the demolition phase of construction, provide extra containers and schedule more frequent pickups.
- Collect, remove, and dispose of all construction site wastes at authorized disposal areas. A local environmental agency can be contacted to identify these disposal sites.

Hazardous materials: The following steps should be taken to ensure the proper disposal of hazardous materials:

- Local waste management authorities should be consulted about the requirements for disposing of hazardous materials.
A hazardous waste container should be emptied and cleaned before it is disposed of to prevent leaks.

The original product label should never be removed from the container. It contains important safety information. Follow the manufacturer's recommended method of disposal, which should be printed on the label.

If excess products need to be disposed of, they should never be mixed during disposal unless specifically recommended by the manufacturer.

Paint and dirt are often removed from surfaces by sandblasting or pressure washing. Sandblasting grits and pressure wash water are the byproducts of these procedures and consist of the sand or water used and the paint and dirt particles that are removed from the surface. These materials can be hazardous if they are removed from older structures because they are more likely to contain lead-, cadmium-, or chrome-based paints. To ensure proper disposal of sandblasting grits and pressure wash water, a licensed waste management or transport and disposal firm should be contracted.

Storage and disposal: The following are ways to ensure proper storage and disposal of materials:

- Cover and stabilize topsoil stockpiles to reapply when revegetating the site.
- Locate pollutant sources such as access roads, borrow areas, and material stockpiles away from critical areas such as steep slopes, highly erodible soils and areas that drain directly into sensitive water bodies.

Phosphorus- and nitrogen-containing fertilizers are used on construction sites to provide nutrients necessary for plant growth, and phosphorus- and nitrogen-containing detergents are found in wash water from vehicle cleaning areas. Excesses of these nutrients can be a major source of water pollution. Management practices to reduce risks of nutrient pollution include the following:

- Apply fertilizers at the minimum rate and to the minimum area needed.
- Work the fertilizer deeply into the soil to reduce exposure of nutrients to storm water runoff.
- Apply fertilizer at lower application rates with a higher application frequency.
- Ensure that erosion and sediment controls are in place to prevent fertilizers and sediments from being transported offsite.
- Use detergents only as recommended, and limit their use on the site. Wash water containing detergents should not be dumped into the storm drain system—it should be directed to a sanitary sewer or be otherwise contained so that it can be treated at a wastewater treatment plant.

2.3.6.3 Information Resources

- **Storm Water Best Management Practice Handbook: Construction** (starting on page 279 of [http://www.cahmphandbooks.org/Construction.asp](http://www.cahmphandbooks.org/Construction.asp)): This manual, developed for California, deals with construction activities and is specifically geared for construction site operators covered.

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under the NPDES general permit. It includes fact sheets for many erosion and sediment control and waste/material management practices.

- **The California Department of Pesticide Regulation Web site**
  (http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/main.cfm): This site contains the School Integrated Pest Management Program page and a series of fact sheets for pesticide use in noncrop settings (published in both English and Spanish), which are accessible at http://www.cdpr.ca.gov/docs/whs/psi2menu. These fact sheets include safety requirements for pesticide handlers, pesticide storage, transportation and disposal, use of engineering controls, first aid and decontamination, respiratory protection, worker safety regulations, laundering pesticide contaminated clothing, hazard communication requirements for employees handling pesticides, and minimal exposure pesticides in noncrop settings. Other pesticide resources that can be helpful include the following:

- **Lawn Care Tips** (http://www.cdpr.ca.gov/docs/factshts/lawn15.pdf)

- **Pesticides and Proposition 65** (http://www.cdpr.ca.gov/docs/factshts/prop65.htm)

- **Consumer Articles Treated with Pesticides**
  (http://www.epa.gov/pesticides/factsheets/treatart.htm)

- **Pesticide Storage and Disposal**
  (http://www.cdpr.ca.gov/docs/factshts/storage.pdf) [Spanish
  (http://www.cdpr.ca.gov/docs/factshts/storage-s.pdf)]
2.3.7 Management Measure 3.3A
Runoff from Existing Development
Existing Development

Management Measure

Develop and implement watershed management programs to reduce runoff pollutant concentrations and volumes from existing development:

1. Identify priority local and/or regional watershed pollutant reduction opportunities (e.g., improve existing urban runoff control structures);
2. Specify a schedule for implementing appropriate controls;
3. Limit destruction of natural conveyance systems; and
4. Where appropriate, preserve, enhance, or establish buffers along surface waters and their tributaries.

2.3.7.1 Programs

The California Department of Transportation (Caltrans) is conducting a series of Retrofit Pilot Studies for modifying existing infrastructure such as facilities and highways to address water quality. A number of different management practices are being studied, including biofiltration, infiltration basins and trenches, catch basin inserts, detention basins, and media filters (http://www.dot.ca.gov/hq/env/stormwater/ongoing/pilot_studies/index.htm).

The Model Urban Runoff Program was developed by the City of Monterey, in conjunction with the City of Santa Cruz, Monterey Bay National Marine Sanctuary, California Coastal Commission, Association of Monterey Bay Area Governments (AMBAG), and Woodward-Clyde Consultants. The program provides guidance to small municipalities that need to meet NPDES Phase II requirements (http://www.swrcb.ca.gov/stormwtr/murp.html).

The Watershed Information Technical System (WITS), developed by the California Environmental Resources Evaluation System (CERES), is a program that provides the information and tools to support local watershed planning, restoration, monitoring, and education. CERES and WITS are programs of the California Resources Agency (http://ceres.ca.gov/watershed/).

The Urban Creeks Council of California works to protect and restore waterways in urban areas through shoreline stabilization, the establishment and protection of buffers and riparian zones, and educational programs for the general public (http://www.urbancreeks.org/).

The County of San Diego’s Project Clean Water is a watershed-based approach to integrating regional efforts at improving water quality. The project includes the development of technical guidance for watershed-based urban runoff programs, education and outreach, and the development of a repository for water quality information in the region (http://www.projectcleanwater.org/index.html).
2.3.7.2 Management Practices

Watershed management programs facilitate the prioritization of NPS pollutants and the development of implementation strategies for mitigating the effects of those priority pollutants. By addressing NPS pollution on a watershed basis, managers can ensure that retrofit projects are consistent with overall water quality goals. Watershed management programs for existing development can be used to achieve these three objectives:

- Reduction of pollutant loads from storm water runoff
- Reduction of the volume of storm water runoff, particularly to reduce erosion on streambanks and conveyance systems
- Implementation of nonstructural controls such as the preservation and enhancement of natural buffers along water bodies

There are a number of structural practices that address runoff volume and pollutant loads in urban storm water. In developed areas, however, space is often limited, requiring that retrofit opportunities and nonstructural practices be employed. Retrofitting involves modifying existing runoff structures by enlargement, modification of inflow and outflow characteristics, and increasing detention time to remove sediment and other pollutants.

The following are structural practices (including retrofits) suitable for urban areas:

- Devices that fit into the storm water conveyance system, such as sand filters, trash racks, and water quality inlets
- Modification of existing storm water ponds, drainage pipe outfalls, and the upstream end of road culverts
- Infiltration practices in or near parking lots (bioretention, porous pavement, sand filters and underground vaults)

Once applicable management practices are identified, areas within each watershed can be prioritized for implementation based on site characteristics such as location, ownership, drainage area, soils, and other conditions that may be applicable to specific management practices. These site assessments are conducted using existing data, such as aerial photographs, zoning maps and GIS data, and field surveys.

Where possible, modification of natural drainage patterns should be avoided. Increasing impervious areas by paving and curbing contributes to water quality degradation by increasing peak flows and preventing the natural storm water treatment functions performed by vegetated areas. It is beneficial to route storm water over vegetated buffers, infiltration devices, or other pervious areas. Converting channelized storm water to sheet flow thus increasing its flow path allows these natural infiltration techniques to function properly and remove pollutants. Another option is using open vegetated swales in place of conventional conveyance devices.

In addition to identifying, prioritizing, and implementing management practices for controlling runoff volume and pollution, water quality in urban areas can be protected by restoring streams, preserving buffers, and stabilizing streambanks. Steam restoration involves reestablishing instream habitat structure and riparian cover, stabilizing channel morphology, protecting critical stream substrates, and mitigating the cause of degradation, if possible. Buffers along streams should be preserved and restored, and streambank stabilization techniques can help reduce erosion and provide habitat.
Nonstructural practices are also well suited for developed areas, because they help to control pollution at its source. Techniques that disconnect runoff from conveyance systems (e.g., rain barrels) and urban forestry practices can serve as nonstructural retrofits. Other nonstructural practices applicable to existing development include education and outreach programs, the establishment and preservation of buffers along water bodies, and ordinances to preserve pervious areas within developed areas. Green space goals can be set to promote tree plantings and pavement reclamation projects.

2.3.7.3 Information Resources

**Structural Practices and Retrofits**

- **U.S. Department of Transportation, Federal Highway Administration, Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring** (http://www.fhwa.dot.gov/environment/ultraurb/index.htm): This online manual provides guidance on storm water management in developed urban areas that have limited space for treatment practices. The intent is to promote technology that is cost-effective and low-maintenance for the ultra-urban environment.

- **USEPA, National Menu of Best Management Practices, Post-Construction Storm Water Management Fact Sheets** (http://cfpub2.epa.gov/npdes/stormwater/menuofbmps/post.cfm): These fact sheets provide guidance on a number of management practices applicable to existing development.

- **County of San Diego’s Project Clean Water, Existing Residential Areas Model Program Guidance** (http://www.projectcleanwater.org/pdf/Model Program - Residential Areas.PDF): This document outlines a number of management practices appropriate for existing residential development, as well as an implementation strategy.

**Nonstructural Practices**

- **Northern Virginia Regional Commission, Nonstructural Urban BMP Handbook** (http://www.novaregion.org/bmp.htm): This manual provides watershed managers, planners, and engineers with guidance on the implementation of nonstructural practices.

- **Low Impact Development Center Web site** (http://www.lowimpactdevelopment.org/): This resource contains technical references for implementing low impact development techniques and has case studies of sites where these practices have been successfully implemented.

**Urban Stream Restoration and Buffers**

- **California Department of Water Resources, Planning and Local Assistance, Urban Stream Restoration Program** (http://www.watershedrestoration.water.ca.gov/urbanstreams): This program provides funding for projects to assist communities in reducing damages from streambank and watershed instability and floods while restoring the environmental and aesthetic values of streams. The Web site offers an overview of past projects funded by the program as well as guidelines for project proposals.

- **Stormwater Manager’s Resource Center** (http://www.stormwatercenter.net/): The Stormwater Manager’s Resource Center provides resources for those involved in local storm water management. These resources include several resources pertaining to aquatic buffers and restoration practices.
California Water Plan Update 2005

California Nonpoint Source Encyclopedia

Urban Areas

- **USEPA, Model Ordinance for Aquatic Buffers**
  [http://www.epa.gov/owow/nps/ordinance/mol1.htm](http://www.epa.gov/owow/nps/ordinance/mol1.htm): This model ordinance can serve as a guide for municipalities looking to establish stream buffers.

- **Ann Riley, Urban Stream Restoration: A Video Tour of Ecological Restoration Techniques**
  [http://www.noltemedia.com/nm/urbanstream/](http://www.noltemedia.com/nm/urbanstream/): This video, which is 61 minutes long and can be ordered online, is a documentary tour of six urban stream restoration sites. It provides background information on funding, community involvement, and the history and principles of restoration. The demonstration includes examples of stream restoration in very urbanized areas, re-creating stream shapes and meanders, creek daylighting, soil bioengineering, and ecological flood control projects.

- **Ohio Department of Natural Resources, Stream Management Guide Fact Sheets**
  [http://www.dnr.state.oh.us/water/pubs/fs_st/streamfs.htm](http://www.dnr.state.oh.us/water/pubs/fs_st/streamfs.htm): This is a compilation of fact sheets on technical guidance for streambank and instream practices, general stream management, and stream processes.


- **USDA NRCS, Watershed Technology Electronic Catalog**
  [http://www.wcc.nrcs.usda.gov/wtec/wtec.htm](http://www.wcc.nrcs.usda.gov/wtec/wtec.htm): This online catalog is a source of technical guidance on a variety of restoration techniques and management practices, to provide direction for watershed managers and restoration practitioners. The site is focused on providing images and conceptual diagrams.

- **USDA NRCS, Buffer Strips: Common Sense Conservation**

**Monitoring Documents**

  [http://www.dot.ca.gov/hq/env/stormwater/special/guidance_manual/index.htm](http://www.dot.ca.gov/hq/env/stormwater/special/guidance_manual/index.htm): This manual covers the entire process of storm water monitoring, with sections that describe the following topics: purpose and objectives; site, constituent, and monitoring method and equipment selection; sampling and analysis plan development; installation and maintenance of equipment; training; logistics; sample collection; quality assurance/quality control (QA/QC); preparation of laboratory samples and analytical methods, QA/QC data evaluation, and data reporting protocols.

**2.3.7.4 Case Study**

*Santa Monica Bay Restoration Project*. The purpose of this project was to evaluate the feasibility and effectiveness of catch basin inserts in addressing storm water pollutant loads into Santa Monica Bay. The devices cost less than $1,000 per catch basin and required an average maintenance frequency of once annually. The three components of the project were

- Characterization of local storm water runoff and selecting target pollutants
- Evaluating catch basin retrofits
- Conducting feasibility and cost-benefit analysis for inter-city retrofit scenarios

This project laid the framework for the development of decision frameworks for municipalities looking to develop retrofit programs. The framework, in the form of a decision tree, helps planners select devices based on local conditions, feasibility, effectiveness, cost and maintenance requirements (http://www.epa.gov/owow/estuaries/coastlines/janfeb99/center/insert.html).

**BMP House Demonstration Project.** The City of Los Angeles and TreePeople conducted a demonstration project that involved retrofitting a single-family home with multiple management practices. This included a Cistern Collection System, Vegetated/ Mulched Swale, Retention Grading, and Driveway Dry Well (http://www.lacity.org/SAN/wpd/index.htm).

### 2.3.7.5 References

2.3.8 Management Measure 3.4A
Onsite Disposal Systems (OSDSs)
New OSDSs

Management Measure

1. Ensure that new OSDSs are located, designed, installed, operated, inspected, and maintained to prevent the discharge of pollutants to the surface of the ground and, to the extent practicable, reduce the discharge of pollutants into ground water. Where necessary to meet these objectives;
   a. Discourage the installation of garbage disposals to reduce hydraulic and nutrient loadings;
   b. Install low-volume plumbing fixtures in new developments or redevelopments as required by State law; and
   c. Encourage installation of low-volume plumbing fixtures in existing developments. Implement OSDS inspection schedules for pre-construction, construction, and post-construction.

2. Direct placement of OSDSs away from unsuitable areas. Where OSDS placement away from unsuitable areas is not practicable, ensure that the OSDS is designed or sited at a density so as not to adversely affect surface waters or ground water. Unsuitable sites include areas
   a. With poorly or excessively drained soils;
   b. With shallow water tables or high seasonal water tables;
   c. Within floodplains; or
   d. Where nutrient and/or pathogen concentrations in the effluent cannot be sufficiently treated or reduced before the effluent reaches sensitive water bodies.

3. Establish protective setbacks from surface waters, wetlands, and floodplains for conventional as well as alternative OSDSs. The lateral setbacks should be based on soil type, slope, hydrologic factors, and type of OSDS. Where uniform protective setbacks cannot be achieved, site development with OSDSs so as not to adversely affect water bodies or contribute to a public health nuisance.

4. Establish protective separation distances between OSDS system components and ground water. The separation distances should be based on soil type, distance to ground water, hydrologic factors, and type of OSDS.

5. Where conditions indicate that nitrogen-limited surface waters may be adversely affected by excess nitrogen loadings from ground water, prohibit the installation of OSDSs or require the installation of OSDSs that reduce total nitrogen loadings to meet water quality objectives.

2.3.8.1 Introduction
When new areas are being developed, sometimes housing and businesses outpace municipal services such as sewers, resulting in the need for treatment of sewage in an individual or small-scale manner at a home.
or business. These systems are also needed in areas where development density is low, causing sewerage projects to be prohibitively expensive compared with the number of customers served. Systems for storing and treating small residential and commercial waste streams are called onsite sewage disposal systems, or OSDSs. OSDSs typically consist of a septic tank for storage and a subsurface soil absorption field (USEPA, 2002a). Buried in the ground, septic tanks are essentially watertight, single- or multiple-chamber sedimentation and anaerobic digestion tanks. They are designed to receive and pretreat domestic wastewater, mediate peak flows, and keep settleable solids, oils, scum, and other floatable material out of the soil absorption field. Wastewater effluent is discharged from the tank and passes through pipes to a series of underground perforated pipes or perforated pipe wrapped in synthetic material. From there, the partially treated effluent flows onto and through the soil infiltrative surface, and finally into the subsurface wastewater infiltration system medium (i.e., soil). Treatment occurs in the septic tank, on and within the biomat that forms at the soil infiltrative surface, and in the soil (or other medium); it then continues as the effluent moves through the underlying soil profiles. Treated effluent that is not drawn into plant roots, incorporated into microbial biomass, or evaporated ultimately reaches ground water and possibly nearby surface waters.

Alternative or innovative systems such as mound systems, fixed-film contact units, wetlands, aerobic treatment units (“package plants”), low-pressure drip applications, and cluster systems, are used in areas where conventional soil-based systems cannot provide adequate treatment of wastewater effluent (USEPA, 2002a). Areas that might not be suitable for conventional systems are those with nearby nutrient-sensitive waters, high densities of existing conventional systems, highly permeable or shallow soils, shallow water tables, large rocks or confining layers, and poorly drained soils. Alternative or innovative systems feature components and processes designed to promote degradation and/or treatment of wastes through biological processes, oxidation/reduction reactions, filtration, evapotranspiration, and other processes. Cluster systems can be used to collect and treat wastewater from multiple facilities at a common site (e.g., lagoon, wetland, infiltration field). Alternative, innovative, and cluster systems often require individual septic tanks for each facility served to provide primary treatment and minimize fat, oil, grease, and solids loadings to secondary treatment units. (Note: Cluster systems that serve 20 or more people may be regulated by a federal, State, and/or local Underground Injection Control Program for Class V facilities. For more information, see http://www.epa.gov/safewater/uic.html.)

2.3.8.2 Programs

The California Wastewater Training and Research Center (CWTRC) conducts research and provides training and education on management practices for wastewater treatment. The Center’s Web site contains technical guidance documents and articles, links to important local, State, and federal programs, and information on training opportunities (http://www.csuchico.edu/cwtrc/).

The California Onsite Wastewater Association (COWA) supports the use of management practices related to onsite wastewater treatment systems. The COWA Web site provides links to relevant information for engineers and government agencies, as well as links to county health departments (http://www.cowa.org/).

County health departments generally regulate OSDSs, but Regional Boards also have the authority to regulate them. Note that OSDSs are prohibited in some areas, such as where receiving waters are nutrient or pathogen sensitive, where there is a high density of existing OSDSs, or where geologic conditions prevent adequate treatment of sewage. Check with your county government to determine what types of systems are allowed in your area.
2.3.8.3 Management Practices

Management practices for new onsite sewage disposal systems are focused on permitting and installation. These practices fall into the following four categories:

- Comprehensive planning by the regulatory authority, including measures to protect sensitive areas, such as nutrient-limited waters and shellfish harvest areas. Measures might include prohibitions, setbacks, or requirements for the use of innovative treatment systems to effect greater treatment of sewage.
- Performance-based requirements for the siting, design, and installation of systems
- Training and certification programs
- Inspection of newly installed systems

The first practice is the development a comprehensive plan that establishes and implements a management entity, develops an internal planning processes, and coordinates with the overall land use planning process. By coordinating wastewater management with land use planning, the plan can address the protection of sensitive areas, basic guidelines as to where conventional or alternative systems will be allowed, maximum densities for disposal systems, and consideration of alternative solutions such as the extension of sewer lines for developing areas (USEPA, 2002a, 2002b).

Specific requirements should be developed for the selection, siting, design, and installation of onsite disposal systems. There are four components to this measure (USEPA, 2002a):

1. Develop performance-based programs with specific goals and criteria that address public health and water quality
2. Model system performance to determine the long-term impacts of OSDSs on water resources
3. Develop criteria for siting OSDSs, such as setback guidelines and official maps showing areas where conditions are suitable for installation. Design criteria should consider the following:
   - Wastewater characterization and expected effluent volumes
   - Site conditions (e.g., soils, geology, ground water, surface waters, topography, structures, property lines)
   - System capacity, based on estimated peak and average daily flows
   - Location of tanks and appurtenances
   - Tank dimensions and construction materials
   - Alternative tank effluent treatment units and configuration
   - Required absorption field dimensions and materials
   - Requirements for alternative soil absorption field areas
   - Sizing and other acceptable features of system piping
   - Separation distances from other site features
   - Operation and maintenance requirements (access risers, safety considerations, inspection points)
   - Accommodations required for monitoring (USEPA, 2002b)
4. Develop site evaluation procedures to assess the suitability of specific technologies. Evaluation
   techniques are based on soils, hydrogeology, or multiple factors, such as soils, climate, ground
   water, onsite disposal system densities, and distance to water resources. The following are
   procedures for site evaluation (USEPA, 2002a; ASTM, 1995; ASTM, 1996):

   - Preliminary documentation (site survey maps, soil surveys, aerial photos, regulations and
     setbacks, loading rates)
   - Identification of unsuitable areas (water supply separation distances, buffer zones and
     setbacks, limiting physiographic features)
   - Subsurface investigations (depth to ground water, soil profiles, percolation tests)
   - Identification of recommended OSDS site (data integration, selection of preferred areas,
     gravity-based flow assessment, final selection)

   The third practice involves the implementation of education, training, licensing and/or certifications for
   site evaluators, installers, designers, and inspectors. Certification and licensing of service providers can
   help ensure program effectiveness and compliance and reduce administrative burdens. Professional
   programs are typically the mechanism for certification, and include required coursework or training; an
   assessment of knowledge, skills, and professional judgment; past experience; and demonstrated
   competency. Most licensing programs also require attendance at continuing education workshops
   (USEPA, 2002b).

   Finally, the onsite disposal system should be inspected at various stages during and after installation. A
   post-construction inspection program should ensure that systems were installed properly, design
   specifications were followed, and soil absorption field areas were not compacted during construction.
   Inspections can be conducted by management personnel or trained/certified inspectors (USEPA, 2002a,
   1993). If necessary, repairs, replacements, or upgrades should be made to septic systems to meet
   performance requirements.

2.3.8.4 Information Resources

Selection of Treatment Technologies

- National Small Flows Clearinghouse, Environmental Technology Initiative (ETI) Fact
  Sheets (http://www.nesc.wvu.edu/nsfc/nsfc_etifactsheets.htm): The ETI fact sheets describe
  innovative and alternative onsite wastewater treatment technologies for single families, clusters of
  homes, subdivisions, and communities. For each technology, general and technical fact sheets are
  available. The fact sheets were created as part of USEPA’s Environmental Technology Initiative.

- WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System, Septic
  Systems (http://www.water.ncsu.edu/watershedss/dss/wetland/aqlife/septic.html - mm): This fact
  sheet describes management practices for onsite wastewater treatment systems, including
  alternative treatment technologies such as denitrification systems and regulatory practices such as
  restrictions on garbage disposals and chemical additives.

- USEPA, Technology Fact Sheets (http://www.epa.gov/owm/mtb/decent/technology.htm): These
  fact sheets discuss advantages and disadvantages, design criteria, performance, costs, examples of
  installations, and references for various onsite treatment technologies.

System Siting, and Design and Management


- **USEPA, Design Manual: Onsite Wastewater Treatment and Disposal Systems** ([http://www.epa.gov/ORD/NRMRL/Pubs/625180012/625180012.htm](http://www.epa.gov/ORD/NRMRL/Pubs/625180012/625180012.htm)): This document, published in 1980, is a technical resource for basic onsite wastewater treatment systems. Recently, USEPA released an update to this document, the *Onsite Wastewater Treatment Systems Manual*, with supplementary information and a discussion of new technologies. USEPA recommends that the documents be used together.

- **USEPA, Onsite Wastewater Treatment Systems Manual** ([http://www.epa.gov/ORD/NRMRL/Pubs/625R00008/625R00008.htm](http://www.epa.gov/ORD/NRMRL/Pubs/625R00008/625R00008.htm)): This document is an update and companion to the 1980 Design Manual. It contains supplementary information on management techniques and recent technological developments.

- **Michael T. Hoover, Ph.D. A Framework for Site Evaluation, Design, and Engineering of On-Site Technologies Within a Management Context** ([http://www.state.ma.us/dep/brp/wwm/files/hoovered.doc](http://www.state.ma.us/dep/brp/wwm/files/hoovered.doc)): This document was written as part of a statewide effort to incorporate watershed-specific performance standards into the Massachusetts onsite wastewater management program. It outlines options for various technologies, siting and design considerations, cost information, and management techniques for decentralized OSDSs.

- **County of San Diego, Land Use Program Guidelines** ([http://www.sdcounty.ca.gov/deh/lwq/land_use/guideline.html](http://www.sdcounty.ca.gov/deh/lwq/land_use/guideline.html)): This Web site contains a number of guidance documents pertaining to the siting, design, and maintenance of onsite wastewater treatment systems as regulated in San Diego.

**Training and Certification Programs**

- **California State University Office of Water Programs** ([http://www.owp.csus.edu/training.htm](http://www.owp.csus.edu/training.htm)): The Office of Water Programs at the California State University, Sacramento, College of Engineering and Computer Science offers training on the operation and maintenance of wastewater facilities. Documentation and videos as well as distance learning courses are available.


- **California Wastewater Training and Research Center** ([http://www.csuchico.edu/cwtrc/index.html](http://www.csuchico.edu/cwtrc/index.html)): The Center conducts training and workshops on wastewater treatment, including onsite wastewater treatment systems.

### 2.3.8.5 Case Study

**Hunters Point Shipyard Decentralized Wastewater Treatment.** This study, conducted by the San Francisco Public Utilities Commission, examined the applicability, costs, benefits, and limitations of various alternative treatment approaches. Onsite treatment systems investigated included conventional single and clustered systems, as well as a small satellite treatment facility. The project also involved public outreach and the development of technical resources ([http://sfwater.org/detail.cfm/MC_ID/7/MSC_ID/60/MTO_ID/112/C_ID/1532/](http://sfwater.org/detail.cfm/MC_ID/7/MSC_ID/60/MTO_ID/112/C_ID/1532/)).

**University of Rhode Island Onsite Wastewater Training Center.** The Center conducts demonstrations of onsite treatment technology, educates and trains both homeowners and wastewater industry personnel, and provides assistance to municipalities in the development of onsite wastewater management programs ([http://www.epa.gov/nps/Section319III/inform_ri.htm](http://www.epa.gov/nps/Section319III/inform_ri.htm)).
2.3.8.6 References


2.3.9 Management Measure 3.4B  
**Onsite Disposal Systems (OSDS)  
Operating OSDSs**

**Management Measure**

Establish and implement policies and systems to ensure that existing OSDSs are operated and maintained to prevent the discharge of pollutants to the surface of the ground and, to the extent practicable, reduce the discharge of pollutants into ground water. Where necessary to meet these objectives, encourage the reduced use of garbage disposals, encourage the use of low-volume plumbing fixtures, and reduce total phosphorus loadings to the OSDS by 15 percent (if the use of low-level phosphate detergents has not been required or widely adopted by OSDS users). Establish and implement policies that require an OSDS to be repaired, replaced, or modified when the OSDS fails or threatens or impairs surface waters.

Inspect OSDSs at a frequency adequate to ascertain whether the OSDSs are failing.

Consider replacing or upgrading OSDSs to treat influent so that total nitrogen loadings in the effluent are reduced to meet water quality objectives. This provision applies only where (a) conditions indicate that nitrogen-limited surface waters may be adversely affected by significant ground water nitrogen loadings from an OSDS, and (b) nitrogen loadings from OSDSs are delivered to ground water.

This management measure deals with the programmatic aspects of OSDS management. The goals are to ensure that systems that are installed as designed are inspected and maintained regularly to prevent failures. Public education about proper sewage disposal system use and maintenance is an important part of this measure, as is development and enforcement of policies to prevent or minimize the impacts of OSDS failures.

### 2.3.9.1 Programs

County health departments generally regulate OSDSs, but Regional Boards also have the authority to regulate them. Note that OSDSs are prohibited in some areas, such as where receiving waters are nutrient or pathogen sensitive, where there is a high density of existing OSDSs, or where geologic conditions prevent adequate treatment of sewage. Check with your county government to determine what types of systems are allowed in your area. Below are several examples of municipal programs in California.

- **The Stinson Beach County Water District**’s Onsite Wastewater Management Program, established in 1978, manages the permitting and inspection of onsite wastewater treatment systems and conducts water quality monitoring. The County Water District is responsible for the introduction of special treatment systems designed specifically to address problems with water tables and poor percolation rates ([http://stinson-beach-cwd.dst.ca.us/guide/hog1.htm](http://stinson-beach-cwd.dst.ca.us/guide/hog1.htm)).

- **The Marin County Septic Systems Program** evaluates and permits onsite sewage systems, as well as gray water systems and septage haulers. The program’s Web site contains procedures for conducting performance inspections, fee schedules, background information on septic systems, links to articles with maintenance information for homeowners, and relevant regulations ([http://www.co.marin.ca.us/depts/CD/main/comdev/ehs/septic/septic_systems.cfm](http://www.co.marin.ca.us/depts/CD/main/comdev/ehs/septic/septic_systems.cfm)).
The Town of Paradise established the Onsite Wastewater Management Zone (OWMZ) in Butte County, California, in 1992 to issue permits for new septic systems and for repairs of operating systems. Trained service providers conduct inspections and maintenance activities. The program is financed by operating permit fees, which are reported to be under $15 a year and are included in water bills. (http://pasture.ecn.purdue.edu/~epados/septics/septic/manage.htm - Town of Paradise, California).

2.3.9.2 Management Practices

The key to managing existing onsite disposal systems is an effective operation and maintenance program. Operation and maintenance programs should include system inventories; management, operation, and maintenance policies; inspection and monitoring requirements; guidelines for the disposal or reuse of residuals; and public education.

Inventories of existing onsite disposal systems are an important step in developing an operation and maintenance program. To the extent possible, information on the location, type, date of installation, date of last service, and owner contact information should be maintained. This may require cooperative agreements between agencies.

Management programs can be implemented by regulatory agencies, wastewater utilities or districts, or as voluntary programs. The specific approach should reflect the needs and available resources of the community. USEPA’s Voluntary National Guidelines for the Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems (http://www.epa.gov/owm/mtb/decent/download/guidelines.pdf) describes in greater detail the various aspects of a management program, and includes case studies, technology fact sheets, and other resources.

Inspection and maintenance programs ensure that systems are performing properly. They can be administered through a training program for homeowners, contracts with certified operators, or the management entity itself. System performance can be determined by visual, bacteriological, physical, chemical, and remote monitoring assessment techniques. An effective inspection, monitoring, operation, and maintenance program includes the following (USEPA, 2002b):

- Specified intervals for required inspections (e.g., every 3 months, every 2 years, or at the time of property transfer or change of use)
- Legal authority to access system components for inspections, monitoring, and maintenance
- Monitoring of overall operation and performance, including remote sensing and failure reporting for highly mechanical and complex systems
- Monitoring of receiving environments at compliance boundaries to meet performance requirements
- Review of system use or flow records, (e.g., water meter readings)
- Required type and frequency of maintenance for each technology
- Identification, location, and analysis of system failures
- Correction schedules for failed systems through retrofits or upgrades
- Record keeping on systems inspected, results, and recommendations

In addition to ensuring the proper functioning of the system components, the effectiveness of the system as a whole can be improved through water conservation and pollutant reduction practices. This can be
achieved through regulations or public education programs that discourage or prohibit the use of garbage
disposals and the disposal of phosphate-containing detergents and household cleaners.

Guidelines for the disposal of residuals are necessary to ensure proper handling and disposal of sludge
(septage) removed from septic tanks. Septage is usually managed via land application, treatment at a
wastewater treatment plant, or treatment at a special septage treatment plant. State and local septage
management programs that incorporate land application or burial of septage must comply with Title 40 of
the U.S. Code of Federal Regulations (CFR), Parts 503 and 257. USEPA has published specific guidance
on these topics (Process Design Manual: Land Application of Sewage Sludge and Domestic Septage,

Finally, public education and outreach are important to improve homeowner and industry awareness of
the importance of operation and maintenance procedures. Databases with septic system inventories can be
used to distribute maintenance information to homeowners. Typical public outreach and education
programs address the benefits of the onsite management program, water conservation, and household and
commercial/industrial hazardous waste discharge prevention (USEPA, 2002b).

2.3.9.3 Information Resources

General Resources

- Stormwater Manager’s Resource Center, Septic System Controls
  (http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/SepticSystemControls.htm). This
  fact sheet describes ways to develop a comprehensive management program to reduce
  pollution from septic systems using public outreach and education, regulatory techniques, and
  maintenance programs.

- USEPA, Voluntary National Guidelines for the Management of Onsite and Clustered
  (Decentralized) Wastewater Treatment Systems
  (http://www.epa.gov/owm/mtb/decent/download/guidelines.pdf): Released in March 2003, these
  guidelines are geared toward state, tribal, and local government officials dealing with the
  management of onsite wastewater treatment systems. They outline the components of a
  successful management program, including public education, design, site evaluation, operation
  and maintenance, inspector certification, and funding.

- USEPA, Draft Handbook for the Management of Onsite and Clustered (Decentralized)
  Wastewater Treatment Systems
  (http://www.epa.gov/owm/mtb/decent/handbook.htm): The draft
  handbook is designed to supplement the Voluntary National Guidelines by providing tools for
  program implementation. It is a compilation of case studies, detailed discussions, and
  supplementary material to provide assistance in implementing management programs.

Selection of Treatment Technology

- National Small Flows Clearinghouse, Environmental Technology Initiative (ETI) Fact
  Sheets (http://www.nesc.wvu.edu/nsfc/nsfc_etifactsheets.htm): The ETI fact sheets describe
  innovative and alternative onsite wastewater treatment technologies for single families, clusters of
  homes, subdivisions, and communities. For each technology, general and technical fact sheets are
  available. The fact sheets were created as part of USEPA’s Environmental Technology Initiative.

Homeowner Education
Stinson Beach County Water District, Onsite Wastewater Management Program, Homeowner’s Guide (http://stinson-beach-cwd.dst.ca.us/waste/home.html): This manual provides information for homeowners on septic system function and maintenance, signs of failure, and basic dos and don’ts.

USEPA, Homeowner Education Materials (http://www.epa.gov/owm/mtb/decent/homeowner.htm): These educational materials are available free of charge, either as hard copies or in electronic form. They can be customized to reflect local contact information.

System Inspection, Operation, and Maintenance

D. Friedman, The Septic Information Web site (http://www.inspect-ny.com/septbook.htm): This Web site features a compilation of technical resources; links to industry, government, universities and consultants; and information for homeowners.

WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System, Septic Systems (http://www.water.ncsu.edu/watershedss/dss/wetland/aqlife/septic.html - mm): This fact sheet describes management practices for onsite wastewater treatment systems, including alternative treatment technologies such as denitrification systems and regulatory practices such as restrictions on garbage disposals and chemical additives.

USEPA, Failing Septic Systems Fact Sheet (http://cfpub2.epa.gov/npdes/stormwater/menuofbmps/illi_1.cfm): This fact sheet describes measures to address failing septic systems, and includes cost and effectiveness information.


Septage/Residual Disposal

USEPA, Decentralized Systems Technology Fact Sheet: Septage Treatment/Disposal (http://www.epa.gov/owm/mtb/septage.pdf): This fact sheet provides background information on septage from various sources and details on various options for treatment and disposal of septage.


2.3.9.4 Case Study

Septic System Management Task Force. The Santa Monica Bay Restoration Commission created a Task Force on Septic System Management that involved multiple state and local regulatory agencies, environmental organizations, and health departments. The goals of the Task Force were to address human health and water quality problems related to septic systems and options for improving septic system management in the northern Santa Monica Bay watersheds. Recommendations were based on programs implemented in other states, water quality data, and the current regulatory framework for septic system management. The Commission continues to cooperate with regulatory agencies to assist in the implementation of these recommendations (http://www.santamonicaabay.org/site/programs/layout/task.jsp - 54).

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San Lorenzo River Basin, Wastewater Management Program. This project was developed in order to assist in the development of a management program for existing onsite wastewater treatment systems, including inspection, maintenance, and upgrades. Since 1985, the Santa Cruz County Environmental Health Service has been working to develop a program for inspecting all onsite systems, assessing pollutant loads, and making necessary repairs. Studies conducted through this initiative included calculations of nutrient inputs to the river from onsite systems (http://www.co.santa-cruz.ca.us/eh/env_water_quality/san_lorenzo_wastewater_management_plan_status_report_1996-1998.pdf).

2.3.9.5 References

2.3.10 Management Measure 3.5A
Transportation Development Planning, Siting, and Developing Roads and Highways

Management Measure

Plan, site, and develop roads and highways to:

1. Protect areas that provide important water quality benefits or are particularly susceptible to erosion or sediment loss;

2. Limit land disturbance such as clearing and grading and cut and fill to reduce erosion and sediment loss; and

3. Limit disturbance of natural drainage features and vegetation.

2.3.10.1 Programs

California Department of Transportation (Caltrans), Storm Water Management Program. Caltrans is the agency responsible for managing California’s highway system. With its statewide Storm Water Management Program, Caltrans is helping to prevent the adverse effects of storm water runoff from Caltrans roadways and facilities. This program provides a comprehensive effort to preserve and improve water quality in California (http://www.dot.ca.gov/hq/env/stormwater/index.htm).

Surface Transportation Policy Project (STPP). STPP’s California field offices provide assistance to local transportation agencies, elected officials, and citizen groups in order to help stakeholders take advantage of the new opportunities available under the federal transportation bill to link transportation to land use, housing, social equity, livable communities, and smart growth (http://www.transact.org/ca/environment.htm).

2.3.10.2 Management Practices

The type and location of permanent storm water management practices should be considered when planning highways, roads, and bridges, such that rights-of-way are sized to accommodate structural controls.

Highways and roads should be planned to minimize mileage through areas that might adversely affect sensitive areas, such as wetlands or estuaries. Wetlands that are within the right-of-way and cannot be avoided should be protected with the use of mitigation measures. Highway and road construction should be limited in sensitive areas, and highways should be sited so there is a sufficient setback distance between the highway right-of-way and any wetland or riparian areas. Another consideration is tidal flows to wetlands; highways and rights-of-way should not restrict this flow. Mitigation will likely be required if wetlands, riparian areas, or estuaries are affected.
Curbs can be eliminated (when local development codes permit) to allow highway and road runoff to be filtered through vegetated shoulders and medians. Eliminating curbs also increases infiltration to ground water. If eliminating curbs is not possible, curbs can be designed with breaks to direct runoff to vegetated surfaces. Care must be taken to ensure that the curb breaks do not receive so much runoff as to erode the vegetated infiltration area.

Storm water control structures should be designed so that the storm water does not run directly to receiving waters. This practice is often referred to as disconnecting impervious surfaces. Highway runoff should be routed through a combination of treatment practices or over stabilized vegetated areas before it enters receiving waters.

2.3.10.3 Information Resources

- **Caltrans Environmental Handbook, Volume 3** ([http://www.dot.ca.gov/ser/envhand.htm](http://www.dot.ca.gov/ser/envhand.htm)): This volume provides guidance on the identification and evaluation of biological resources, processing of biological resource documents, and implementation of biologically related construction, maintenance, and encroachment activities. Volume 3 of the Environmental Handbook should be used in conjunction with other project planning and development manuals as well as with Volume 1.

- **Caltrans Environmental Handbook, Volume 5** ([http://www.dot.ca.gov/ser/envhand.htm](http://www.dot.ca.gov/ser/envhand.htm)): This volume, which is still in preparation, will provide guidance on storm water management.

- **Caltrans, Storm Water Management Plan** ([http://www.dot.ca.gov/hq/env/stormwater/special/index.htm](http://www.dot.ca.gov/hq/env/stormwater/special/index.htm)). The plan, approved by the SWRCB in March 2003, describes procedures and practices Caltrans uses to manage pollutants discharged from storm water drainage systems.

- **Caltrans Internet Water Quality Planning Tool** ([http://www.dot.ca.gov/hq/env/stormwater/index.htm](http://www.dot.ca.gov/hq/env/stormwater/index.htm)): Available only on the Internet, the Water Quality Planning Tool is a database of water quality standards and possible pollutants from Caltrans facilities. This unique tool is another valuable resource being used by Caltrans in its continuing commitment to prevent storm water pollution.

- **California Wetland Information System** ([http://ceres.ca.gov/wetlands/](http://ceres.ca.gov/wetlands/)): The California Wetland Information System is designed to provide wetland information to the public, educational community, and government agencies. It includes information on wetland mitigation and the mitigation role and responsibility for the California Department of Transportation ([http://ceres.ca.gov/wetlands/agencies/caltrans.html](http://ceres.ca.gov/wetlands/agencies/caltrans.html)).

- **Washington Department of Transportation, Roadside Manual** ([http://www.wsdot.wa.gov/eesc/design/roadside/default.htm#rm](http://www.wsdot.wa.gov/eesc/design/roadside/default.htm#rm)): The purpose of this manual is to provide guidance on roadside maintenance, including planning, design, construction, and maintenance. The manual has information on sustainable roadways, environmental functions, wetlands, water quality, parking area design, erosion control, contour grading, soil bioengineering, and vegetative restoration concepts.

2.3.10.4 Case Study

**Folsom, California, Dual Drainage System.** In Folsom, an arterial street was outfitted with a dual drainage system, which has separate systems to treat runoff for water quality during smaller storms and runoff quantity and timing during larger storms (Richman et al., 1998). The system consists of grassy swales that use a conventional curb-and-gutter system. Two catch basins are included in the design. The
first basin collects the first flush of rainfall from a 2-year storm and discharges the effluent into a grassy swale for treatment. The treated runoff is then directed into the main storm drainage system. The second catch basin, located downstream, collects flows beyond the 2-year storm (up to a 10-year storm) that are not handled by the first system, and discharges this flow directly to the storm drainage system.

2.3.10.5 References


2.3.11 Management Measure 3.5B
Transportation Development Bridges

**Management Measure**

Site, design, and maintain bridge structures so that sensitive and valuable aquatic ecosystems and areas providing important benefits are protected from adverse effects.

Bridges by their nature are built in riparian areas and can have pronounced habitat and water quality impacts if care is not taken to protect sensitive areas from both construction and post-construction impacts. Practices to meet these goals include designing bridges to minimize damage to riparian or wetland habitats and treating runoff from bridge decks before it is allowed to enter watercourses. Bridge maintenance activities should be conducted using containment practices to prevent pollutants, such as paint, rust, hazardous chemicals, and building materials, from entering the water or riparian habitat below. Restoration of damaged riparian or instream habitats should be done after bridge construction, maintenance, and demolition.

2.3.11.1 Programs

California Department of Transportation (Caltrans) Storm Water Management Program. Caltrans is the agency responsible for managing California’s highway system. With its statewide Storm Water Management Program, Caltrans is helping to prevent the adverse effects of storm water runoff from Caltrans roadways and facilities. This program provides a comprehensive effort to preserve and improve water quality in California (http://www.dot.ca.gov/hq/env/stormwater/index.htm).

Surface Transportation Policy Project (STPP). STPP's California field offices provide assistance to local transportation agencies, elected officials, and citizen groups in order to help stakeholders take advantage of the new opportunities available under the federal transportation bill to link transportation to land use, housing, social equity, livable communities, and smart growth (http://www.transact.org/ca/environment.htm).

Through the Clean Water Act section 401 certification program, RWQCBs review projects that require a federal permit under CWA section 404 or involve dredge or fill activities that may result in a discharge to waters of the United States. This is to ensure that the State's interests are protected on any federally permitted activity occurring in or adjacent to waters of the State. The process for applying for Water Quality Certification under CWA section 401 in California is described on the SWRCB’s Web site (http://www.swrcb.ca.gov/rwqcb2/certs.htm).

2.3.11.2 Management Practices

Bridges should be planned to minimize mileage and protect sensitive areas such as wetlands or estuaries. Setbacks should be used for river crossings during construction to minimize disturbance to the riparian area. Bridge construction can adversely impact water circulation in wetland areas, so allowances should be made for these impacts when designing bridges. Areas requiring excessive cut and fill and those that may be subject to subsidence, sink holes, landslides, rock outcropping, and highly erodible soils should be avoided when siting bridge locations.
Runoff should be directed away from bridge decks and watercourses by diverting it toward land for treatment. This can be accomplished using drains that pipe water along the bridge edge to either side of the shore. Recommended practices for treating bridge deck runoff include ponds, wetlands, infiltration basins and trenches, media filters, bioretention areas, vegetated swales, filter strips, and hydrodynamic devices. The use of scupper drains should be restricted on bridges less than 400 feet long and on bridges crossing sensitive areas.

2.3.11.3 Information Resources

- *Caltrans Environmental Handbook, Volume 3* (http://www.dot.ca.gov/ser/envhand.htm): This volume provides guidance on the identification and evaluation of biological resources, processing of biological resource documents, and implementation of biologically related construction, maintenance, and encroachment activities. Volume 3 of the *Environmental Handbook* should be used in conjunction with other project planning and development manuals and with Volume 1.

- *Caltrans Environmental Handbook, Volume 5* (http://www.dot.ca.gov/ser/envhand.htm): This volume, which is currently in preparation, will provide guidance on storm water management.

- **Caltrans, Storm Water Management Plan** (http://www.dot.ca.gov/hq/env/stormwater/special/index.htm). The plan, approved by the SWRCB in March 2003, describes procedures and practices Caltrans uses to manage pollutants discharged from storm water drainage systems.

- **Caltrans Internet Water Quality Planning Tool** (http://www.dot.ca.gov/hq/env/stormwater/index.htm): Available only on the Internet, the Water Quality Planning Tool is a database of water quality standards and possible pollutants from Caltrans facilities. This unique tool is another valuable resource being used by Caltrans in its continuing commitment to prevent storm water pollution.

- **Washington Department of Transportation, Roadside Manual** (http://www.wsdot.wa.gov/eesc/design/roadside/default.htm - rm): The purpose of this manual is to provide guidance on roadside maintenance, including planning, design, construction, and maintenance. The manual has information on sustainable roadsides, environmental functions, wetlands, water quality, parking area design, erosion control, contour grading, soil bioengineering, and vegetative restoration concepts.

2.3.11.4 Case Study

*North Coast River Loading Study*. This study will look at how storm water runoff from bridges affects water quality, fish, and aquatic life. Sediment, nutrients, and temperature changes will be studied to determine how these pollutants may adversely affect coho salmon and steelhead trout. Information about water quality gathered from this watershed will be valuable for future TMDL (total maximum daily load) studies along the North Coast. It will also provide a basis for future cooperative efforts between Caltrans and watershed landowners working together to reduce stream pollutants (http://www.dot.ca.gov/hq/env/stormwater/index.htm).

*Road Crossings on Small Streams*. Bridge crossings over streams can affect aquatic habitat in several ways. Sediment from eroded banks during and after construction and storm water runoff from bridges can affect water quality and organisms in the streams (http://www.dot.ca.gov/hq/env/stormwater/index.htm).
This study, which is being conducted in the Navarro watershed, will

- Identify the sources of pollution to the major streams in the watershed
- Identify different types of aquatic life within the stream community
- Determine the availability of habitat for salmon and steelhead
- Compare the condition of the riparian area to the health of stream communities
- Investigate the movement of sediment within the stream
- Analyze storm water runoff using standard toxicology tests to determine the effects on living organisms

2.3.11.5 References


2.3.12 Management Measure 3.5C
Transportation Development
Construction Projects

Management Measure

1. Reduce erosion and, to the extent practicable, retain sediment on site during and after construction; and

2. Prior to land disturbance, prepare and implement an approved erosion control plan or similar administrative document that contains erosion and sediment control provisions.

See Management Measure 3.2A for programs, practices, and information resources relating to erosion and sediment control at construction sites. The same practices apply to transportation projects.
2.3.13 Management Measure 3.5D
Transportation Development
Chemical Control

Management Measure

1. Limit application, generation, and migration of toxic substances;
2. Ensure the proper storage and disposal of toxic materials;
3. Apply nutrients at rates necessary to establish and maintain vegetation without causing significant nutrient runoff to surface waters.

See Management Measure 3.2B for programs, practices, and information resources relating to chemical control at construction sites. The same practices apply to transportation projects.
2.3.14 Management Measure 3.5E
Transportation Development
Operation and Maintenance

Management Measure

Incorporate pollution prevention procedures into the operation and maintenance of roads, highways, and bridges to reduce pollutant loadings to surface waters.

Road and bridge maintenance activities can generate pollutants when runoff carries road surfacing materials, sealants, road salt, sand, and deicing chemicals into receiving waters. In addition, soil can erode when rights-of-way are cleared or disturbed. Practices to prevent such pollution include erosion and sediment controls for exposed soils, covering, and surrounding with berms or other secondary containment materials that are stockpiled for maintenance activities. For winter deicing activities, materials to be used should be carefully selected to avoid causing or exacerbating specific water quality problems. For example, where salinity might be a problem in receiving waters, road salt should be avoided and sand used instead.

Motor vehicles generate runoff pollutants through the emission and deposition of automobile exhaust and through discharges of both fluids and solid particles during travel and while braking (USEPA, 2002). These pollutants include hydrocarbons and heavy metals. In a study of traffic-generated particulates in Cincinnati (where the average daily traffic is 150,000 vehicles), Sansalone and Buchberger (1997) found that 15 percent of the 13,500 milligrams (mg) of particulates per square meter of road surface generated per day originated from engine and brake pad wear. The study also found that 6 percent of particulates were deposited from settleable exhaust. The other proportions originated from pavement wear (44 percent to 49 percent), tire wear (28 percent to 31 percent), and atmospheric deposition (3 percent).

2.3.14.1 Programs
California Department of Transportation, Division of Maintenance, Roadside Maintenance Program. This program is responsible for vegetative control and the Adopt-a-Highway Program. (http://www.dot.ca.gov/hq/maint/roadside.htm).

California Department of Transportation, Division of Maintenance, Roadway Maintenance Program. This program manages rehabilitation and maintenance of pavement and snow and ice control (http://www.dot.ca.gov/hq/maint/roadway.htm).

California Department of Transportation (Caltrans) Adopt-A-Highway Program. The Caltrans Adopt-A-Highway Program provides an avenue for individuals, organizations, or businesses to help maintain sections of roadside within California’s State Highway System (http://adopt-a-highway.dot.ca.gov/).

California Department of Pesticide Regulation's (DPR) Surface Water Protection Program. This program protects human health and the environment by preventing pesticides from adversely affecting surface waters, by addressing both agricultural and nonagricultural sources of pesticide residues in surface waters. It has preventive and response components that reduce the presence of pesticides in surface waters (http://www.cdpr.ca.gov/docs/sw/).
2.3.14.2 Management Practices

Road Repairs

Potholes and cracks in road surfaces and retaining walls should be repaired promptly to prevent further degradation of the road surface. When these activities, along with road expansion and repaving, disturb vegetated areas, the exposed soils should be protected from erosion using erosion and sediment controls (see Management Measure 3.2A) and denuded areas should be revegetated using seed, mulch, or sod immediately after road work has been completed.

When performing bridge maintenance activities, use enclosures, and containment and collection systems to collect pollutants. Recommended enclosures include free hanging enclosures, total structure enclosures, and negative pressure systems, and recommended containment and collection systems include: cofferdams, barges, containment booms, and vacuum sanders. A runoff control plan should be in place for each large project, and smaller projects should be governed by standard operating procedures to prevent contamination of storm flows and to control spills.

Winter Maintenance

Chemicals and abrasives used to prevent ice on road surfaces in winter should be stored on an impervious pad and covered to prevent runoff from carrying away any of the materials. Not only does this prevent runoff pollution, but it also preserves the materials for their intended use. Stockpiled deicing materials should not be stored in floodplains.

Deicing materials should be selected and applied to cause minimal harm to the environment. Where areas might be sensitive to salinization, alternatives to road salt, such as sand or any number of organic products that are currently on the market, can be used. Organic products should be avoided in areas that have low biochemical oxygen demand. Sand should not be used in areas with sediment problems such as excessive streambank scour or embedded gravels.

When applying materials, care should be taken to apply only the amount of material that is required to provide a safe road surface. Local studies can be undertaken to determine the appropriate amount of deicing materials to be used for different road surfaces in different conditions and locations.

Snow that is plowed from road surfaces should never be stockpiled on or near frozen surface waters or retention ponds. Once the snow and ice has melted, road surfaces should be swept or vacuumed to remove and reclaim sand, salt, or other deicing chemicals. This material can be recycled or disposed of in a locally approved manner.

Trash and Debris Removal

Streets and parking lots should be periodically swept or vacuumed to remove trash and debris. The frequency with which each area or road is swept should depend on the quantity of trash that is seen over time. Areas that are heavily traveled or tend to attract litter should be swept more frequently. Also, areas that drain to sensitive receiving waters or areas that have known trash and debris problems should be swept more frequently.
Anti-litter signage should be posted throughout the community, especially in places with known trash/debris problems. Litter and dumping laws should be strictly enforced, and the municipality should provide a hotline or other medium for citizens to report littering or dumping.

2.3.14.3 Information Resources

- **Federal Highway Administration**, *Manual of Practices for an Effective Anti-Icing Program: A Guide for Highway Winter Maintenance Personnel* ([link](http://www.fhwa.dot.gov/reports/mopeap/mop0296a.htm)): The manual was written to guide maintenance managers in developing a systematic and efficient practice for maintaining roads in the best conditions possible during a winter storm. It describes the significant factors that should be understood and must be addressed in an anti-icing program, with the recognition that the development of the program must be based on the specific needs of the site or region within its reach. It focuses on the weather information, materials, and methods that will best address site conditions such as level of service, highway agency resources, climatological conditions, and traffic.

- **Transportation Research Board publications** ([link](http://www4.trb.org/trb/onlinepubs.nsf)): The Transportation Research Board has prepared several studies that investigate the environmental impacts of activities related to transportation infrastructure, including such titles as *Assessing the Impacts of Bridge Deck Runoff Contaminants in Receiving Waters, Mitigating Highway Runoff Constituents Via a Wetland, Characteristics of Storm-Water Runoff from Highway Construction Sites in California*, and others.

- **Pacific Northwest Snowfighters Association** ([link](http://www.wsdot.wa.gov/partners/pns/)): This site provides resources on deicing and anti-icing products and practices.

- **California Department of Transportation (Caltrans), Storm Water Management Program** ([link](http://www.dot.ca.gov/hq/env/stormwater/index.htm)). Caltrans is the agency responsible for managing California’s highway system. With its statewide Storm Water Management Program, Caltrans is helping to prevent the adverse effects of storm water runoff from Caltrans roadways and facilities. This program provides a comprehensive effort to preserve and improve water quality in California.

- **Washington Department of Transportation, Roadside Manual** ([link](http://www.wsdot.wa.gov/eesc/design/roadside/default.htm#rm)). The purpose of this manual is to provide guidance on roadside maintenance, including planning, design, construction, and maintenance. The manual has information on sustainable roadides, environmental functions, wetlands, water quality, parking area design, erosion control, contour grading, soil bioengineering, and vegetative restoration concepts.

2.3.14.4 References


2.3.15 Management Measure 3.5F
Transportation Development
Road, Highway, and Bridge Runoff Systems

Management Measure

Develop and implement runoff management systems for existing roads, highways, and bridges to reduce runoff pollutant concentrations and volumes entering surface waters.

1. Identify priority watershed pollutant reduction opportunities (e.g., improvements to existing urban runoff control structures); and

2. Establish schedules for implementing appropriate controls.

This management measure acknowledges the fact that roads built in the past may not have the same level of runoff control and treatment that is expected today. These older roads may be contributing to pollution problems in receiving waters. Municipalities responsible for road and bridge rights-of-way should undertake an assessment of the roads’ and bridges’ contribution to surface waters and identify opportunities for installing new treatment practices. Based on water quality priorities and the availability of staff and funding resources, a schedule should be devised to implement these practices.

2.3.15.1 Programs

Caltrans Storm Water Management Program. Caltrans is the agency responsible for managing California’s highway system. With its statewide Storm Water Management Program, Caltrans is helping to prevent the adverse effects of storm water runoff from Caltrans roadways and facilities. This program provides a comprehensive effort to preserve and improve water quality in California (http://www.dot.ca.gov/hq/env/stormwater/index.htm).

Surface Transportation Policy Project (STPP). STPP’s California field offices provide assistance to local transportation agencies, elected officials, and citizen groups in order to help stakeholders take advantage of the new opportunities available under the federal transportation bill to link transportation to land use, housing, social equity, livable communities, and smart growth (http://www.transact.org/ca/environment.htm).

2.3.15.2 Management Practices

Runoff treatment facilities can be located within existing rights-of-way, medians, or interchange loops, or on adjacent lands (e.g., golf courses and parks). Where no additional land is available, underground runoff storage and treatment (e.g., sand filters) can be used. Vegetative filter strips along roadways and in medians can be effective at slowing runoff velocities and increasing storm water infiltration. Curbs should be eliminated to allow highway and road runoff to be filtered through vegetated shoulders and medians. Eliminating curbs also increases infiltration to ground water. If eliminating curbs is not possible, curbs can be designed with breaks and energy dissipaters to direct sheet flow to vegetated surfaces. These infiltration areas will require periodic inspection for damage, rilling, ponding, and trash accumulation, and will also require mowing or cropping of vegetation to prevent nuisance conditions.
Soil bioengineering techniques can be used in lieu of retaining walls for slope stabilization practices where sloped roadways are deteriorating. Practices such as live stakes, fascines, brush layers, branchpackaging, live gully repair, live cribwalls, vegetated rock gabions, vegetated rock walls, and joint planting are recommended for relatively moderate slopes where vegetation can be established.

### 2.3.15.3 Information Resources

- **Caltrans Environmental Handbook, Volume 5** ([http://www.dot.ca.gov/ser/envhand.htm](http://www.dot.ca.gov/ser/envhand.htm)): This volume, which is still in preparation, will provide guidance on storm water management.


- **Caltrans Internet Water Quality Planning Tool** ([http://www.dot.ca.gov/hq/env/stormwater/index.htm](http://www.dot.ca.gov/hq/env/stormwater/index.htm)): Available only on the Internet, the Water Quality Planning Tool is a database of water quality standards and possible pollutants from Caltrans facilities. This unique tool is another valuable resource being used by Caltrans in its continuing commitment to prevent storm water pollution.

- **Washington State Department of Transportation (WSDOT), Soil Bioengineering** ([http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBWeb site/mainpage/BackgroundInfo/background.htm](http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBWeb site/mainpage/BackgroundInfo/background.htm)): WSDOT has a Web page that provides information on soil bioengineering, from designing projects to costs, funding, contractors, and native plant supplies. The site also showcases past projects and provides links to several online information sources.

- **WSDOT, Roadside and Site Development Unit** ([http://www.wsdot.wa.gov/eesc/design/roadside/default.htm](http://www.wsdot.wa.gov/eesc/design/roadside/default.htm)): The Roadside and Site Development Unit has a roadside technology transfer center that shares information with the public on technologies such as soil bioengineering, revegetation, soils, and permanent erosion control. The **Roadside Manual** ([http://www.wsdot.wa.gov/eesc/design/roadside/default.htm - rm](http://www.wsdot.wa.gov/eesc/design/roadside/default.htm - rm)) provides guidance on roadside maintenance, including planning, design, construction, and maintenance. The manual has information on sustainable roadides, environmental functions, wetlands, water quality, parking area design, erosion control, contour grading, soil bioengineering, and vegetative restoration concepts.

### 2.3.15.4 References


2.3.16  Management Measure 3.6A
Education/Outreach
Pollution Prevention/Education

Management Measure

Implement educational programs to provide greater understanding of watersheds and to raise awareness and increase the use of applicable urban management measures and practices where needed to control and prevent adverse impacts on surface and ground waters. Public education, outreach, and training programs should involve applicable user groups and the community. Implementation of urban pollution prevention and education programs includes the following subjects, where applicable:

1. Households: Improper storage, use, and disposal of household hazardous chemicals, including automobile fluids, pesticides, paints, and solvents; lawn and garden activities, including the application and disposal of lawn and garden care products, and improper disposal of leaves and yard trimmings; improper operation and maintenance of onsite disposal systems; and improper disposal of pet excrement.

2. Landscaping: Turf management on golf courses and in parks and recreational areas.

3. Commercial: Commercial activities, including parking lots, restaurants, vehicle service facilities, and other entities.

4. Other General Sources: Discharge of pollutants (including floatables, waste oil, and litter) into storm drains; roads, highways, and bridges.

2.3.16.1 Programs

California Integrated Waste Management Board (CIWMB). The CIWMB provides assistance with solid waste minimization and pollution prevention. Material-specific guidance, educational materials, and information on financial assistance are provided for industry and the general public (http://www.ciwmb.ca.gov/).

California Department of Toxic Substance Control (DTSC) Pollution Prevention (P2) Program. The P2 Program provides resources for industry, local government, and other environmental agencies to promote source reduction and pollution prevention. This includes technology transfer, inspection/enforcement program support, and public outreach (http://www.dtsc.ca.gov/PollutionPrevention/index.htm).

California Department of Pesticide Regulation, Home2Ocean Program. The Home2Ocean Web site provides information for residential users of pesticides on their proper use and disposal. The Home2Ocean workbook is a capacity-building resource for launching or conducting a public education program for preventing water pollution from household pesticides (http://www.home2ocean.org/index.html).

City of San Diego's Storm Water Pollution Prevention Program. The program aims to reduce pollution in urban runoff through a variety of programs. These include public education, training programs, monitoring for water quality, watershed management, and the development and implementation of management practices (http://www.sannet.gov/stormwater/index.shtml).
Alameda Countywide Clean Water Program (ACCWP). The ACCWP is a consortium of local agencies in Alameda County dedicated to preventing urban storm water pollution. The program grew out of a need to meet NPDES requirements and participate in the development of the Water Quality Control Plan for the San Francisco Bay region. The program engages in efforts to educate the general public, contractors, and government employees through the distribution of literature, information fairs, training workshops, and television ads. In addition, the consortium works to identify and correct illicit discharges into the storm water system (http://www.ci.berkeley.ca.us/PW/Storm/stormala.html).

San Mateo Countywide Stormwater Pollution Prevention Program (STOPPP). STOPPP serves as a community resource for pollution prevention, focusing on educating residential and business communities via publications on management practices, commercials, and training programs (http://www.flowstobay.org/index.html).

California Environmental Protection Agency, Permit Assistance Centers. In addition to helping businesses to comply with permit requirements, this program provides referrals for pollution prevention assistance and other business assistance programs. The Web site lists pollution prevention resources relevant to California businesses (http://www.calgold.ca.gov/P2/).

2.3.16.2 Management Practices
Pollution prevention practices are those that seek to educate the public on the potential for everyday activities to create NPS pollution. Pollution is generated by everyday household activities, commercial and residential lawn and garden care, commercial activities, pet waste, and trash.

Everyday household chemicals can be considered pollutants if they are improperly handled, stored, or disposed of. Automotive substances, household cleaners, fertilizers, pesticides, and home improvement materials must all be carefully managed to prevent contamination of runoff or ground water. Car washing can flush nutrients, metals and hydrocarbons into storm drains. Watershed managers can address these problems through public outreach and education efforts such as pamphlet distribution, training on proper lawn care practices, and storm drain stenciling. Municipalities should also provide facilities for the disposal of household chemicals.

In residential neighborhoods, pet waste can also be a major contributor to NPS pollution. Pet owners can be informed about proper disposal of waste, and municipalities can install “pet waste stations,” pass and enforce “pooper scooper” ordinances, and post signs.

Outreach campaigns should also inform both commercial lawn care specialists and residents of the importance of proper application of fertilizers and pesticides. In particular, techniques such as Integrated Pest Management and timing of fertilizer application should be emphasized to provide citizens with the tools to use these substances efficiently and reduce overall pesticide and fertilizer use.

One way commercial activities can generate NPS pollution is through the release of wastewater into a storm sewer system without a permit (this is known as an illicit discharge). Municipalities must develop programs to help detect and eliminate these illicit discharges, as well as educate businesses and their employees. Commercial and industrial establishments should also implement good housekeeping practices, employee education and training programs and spill prevention plans. Measures should be taken to reduce the possibility of spills or leaks during general operation, maintenance, washing, construction, or repairs and to limit the exposure of pollutants to areas where they might come in contact with storm water.
Finally, municipalities should implement good housekeeping practices, including programs to control trash, debris collected from street sweeping, stockpiled material, and corporation yard pollutant sources, and reduce pollutants from activities such as park and road maintenance. Programs that reduce the amount of trash on the streets include public education, increased waste disposal facilities and cleanup campaigns. Municipalities can also clean streets and prevent trash from entering storm water with street sweeping and trash collection devices for storm drain inlets.

2.3.16.3 Information Resources

General Pollution Prevention Web sites

- **Stormwater Manager’s Resource Center, Fact Sheets on Pollution Prevention Practices** ([http://www.stormwatercenter.net/Assorted Fact Sheets/Tool8-Stewardship/municipal.htm](http://www.stormwatercenter.net/Assorted Fact Sheets/Tool8-Stewardship/municipal.htm)): These fact sheets describe various residential storm water pollution prevention practices.

- **USEPA, Pollution Prevention Information Clearinghouse (PPIC)** ([http://www.epa.gov/opptintr/library/ppicindex.htm](http://www.epa.gov/opptintr/library/ppicindex.htm)): The PPIC houses USEPA documents, pamphlets, and fact sheets on pollution prevention. It also answer questions about pollution prevention and provides referrals for technical assistance and additional information.

- **California Consortium of Pollution Prevention Committees** ([http://www.westp2net.org/c2p2c/c2p2c_main.htm](http://www.westp2net.org/c2p2c/c2p2c_main.htm)): The consortium’s Web site provides links to various pollution prevention organizations in California. The consortium is part of the Western Region Pollution Prevention Network.

- **California Coastal Commission, Model Urban Runoff Program (MURP)** ([http://www.coastal.ca.gov/la/murp.html](http://www.coastal.ca.gov/la/murp.html)): MURP is a step-by-step guide designed for small municipalities to help them manage NPS pollution from urban runoff in California.

Educational Resources

- **American Oceans Campaign, Stormwater Resources** ([http://www.americanoceans.org/runoff/epa.htm](http://www.americanoceans.org/runoff/epa.htm)): This Web site is a compilation of educational resources on storm water pollution specific to California. Fact sheets, brochures, videos and curriculum are available.

- **Orange County Stormwater Program** ([http://www.ocwatersheds.com/PublicEducation/pe_brochures.asp](http://www.ocwatersheds.com/PublicEducation/pe_brochures.asp)): The public education program Web site includes a number of brochures on pollution prevention for residents and businesses. The brochures can be downloaded and printed copies can be ordered.

- **Pierce County, Washington Public Utilities Commission, Stormwater Pollution Prevention Manual** ([http://www.co.pierce.wa.us/PC/services/home/environ/water/swm/sppman](http://www.co.pierce.wa.us/PC/services/home/environ/water/swm/sppman)): This online manual is designed to provide homeowners and businesses with information on pollution prevention.

Residential Pollution Prevention (Household hazardous waste, lawn and garden care, pet waste, car washing)

- **Stormwater Manager’s Resource Center, Fact Sheets on Pollution Prevention Practices** ([http://www.stormwatercenter.net/Assorted Fact Sheets/Tool8-Stewardship/residential.htm](http://www.stormwatercenter.net/Assorted Fact Sheets/Tool8-Stewardship/residential.htm)): 
These fact sheets describe various residential storm water pollution prevention practices, such as pet waste collection, car washing, lawn care, car maintenance, and rain barrels.


**Municipal/Commercial Pollution Prevention**

- **California Municipal Handbook** ([http://www.cabmphandbooks.org/](http://www.cabmphandbooks.org/)): This manual contains information about storm water quality planning for municipal operations, including permit requirements, planning principles, techniques for reducing runoff and managing impervious areas, source controls, runoff treatment controls, staff training, and inspections and maintenance.

- **California Department of Transportation, Maintenance Storm Water Pollution Prevention Bulletin** ([http://svhqsgi4.dot.ca.gov/hq/env/stormwater/publicat/maintain/acrobat.htm](http://svhqsgi4.dot.ca.gov/hq/env/stormwater/publicat/maintain/acrobat.htm)): This is a monthly bulletin that provides technical information on management practices for municipal maintenance activities.

- **USEPA, Phase II Pollution Prevention/Good Housekeeping Fact Sheet** ([http://www.epa.gov/npdes/pubs/fact2-8.pdf](http://www.epa.gov/npdes/pubs/fact2-8.pdf)): This fact sheet describes general requirements and provides guidance for the Phase II Pollution Prevention/Good Housekeeping minimum control measures.

- **Stormwater Manager’s Resource Center, Fact Sheets on Pollution Prevention Practices** ([http://www.stormwatercenter.net/Assorted Fact Sheets/Tool8-Stewardship/municipal.htm](http://www.stormwatercenter.net/Assorted Fact Sheets/Tool8-Stewardship/municipal.htm)): These fact sheets describe various municipal storm water pollution prevention practices for pest control, bridge and roadway maintenance, controlling illegal dumping, catch basin maintenance, and parking lot and street cleaning.

- **CalGold, Pollution Prevention Resources** ([http://www.calgold.ca.gov/P2/default.asp](http://www.calgold.ca.gov/P2/default.asp)): CalGold was established by the California Environmental Protection Agency to help businesses comply with environmental regulations. The Pollution Prevention Resources include a number of industry-specific fact sheets.

- **USEPA, National Menu of Best Management Practices for Storm Water Phase II, Pollution Prevention/Good Housekeeping for Municipal Operations Fact Sheets** ([http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm)): USEPA’s guidance for small NPDES-regulated municipalities describes practices appropriate for municipal crews to reduce pollutants in storm water at their source, including safe material storage and handling practices, vehicle washing, street sweeping, and landscape maintenance. These practices can apply to residents and business owners and operators, as well.

**2.3.16.4 Case Study**

*Pet Pollution Prevention Pledge, Los Angeles County, California.* The Los Angeles County Department of Public Works developed this program to educate residents on the importance of proper disposal of pet waste. The outreach campaign relied on multimedia communication efforts, the distribution of cleanup kits, and the installation of plastic bag dispensers in parks. Local pet and pet supply stores helped with the effort (Lehner et al., 1999) ([http://www.epa.gov/owow/info/NewsNotes/issue53/education53.html-canines](http://www.epa.gov/owow/info/NewsNotes/issue53/education53.html-canines)).
2.3.16.5 References
2.4 Marinas and Recreational Boating

2.4.1 Introduction

The California Management Measures for Polluted Runoff defines 16 management measures to control pollution from marinas and recreational boating. Because marinas are located at the water’s edge, pollutants generated by marinas and boats are less likely to be buffered or filtered by natural processes. When boating and related activities (e.g., marinas and boat maintenance areas) are poorly planned or managed, they may threaten the health of aquatic systems and pose other environmental hazards. USEPA (1993) identifies several sources of pollution associated with marinas and boating activities:

- Poorly flushed waterways
- Pollutants discharged from boats (recreational boats, commercial boats, and “live-aboards”)
- Pollutants carried in storm water runoff
- Physical alteration of wetlands and of shellfish and other benthic communities during construction of marinas, ramps, and related facilities
- Pollutants generated from boat maintenance activities on land and in the water

California’s management measures are intended to be applied to control impacts on water quality and habitat from marina siting and construction (new and expanding marinas), and marina and boat operation and maintenance. The measures are designed to reduce nonpoint source (NPS) pollution by requiring the best possible siting for marinas and maintenance areas, providing for the best available design and construction practices and appropriate operation and maintenance practices, and encouraging the development and use of effective pollution control and education efforts. The management measures cover the following operations and facilities (USEPA, 1993):

- Any facility that contains 10 or more slips, piers where 10 or more boats may tie up, or any facility where a boat for hire is docked
- Any residential or planned community marina with 10 or more slips
- Any mooring field where 10 or more boats are moored
- Public or commercial boat ramps
- Boat maintenance or repair yards that are adjacent to the water, and any federal, State, or local facility that involves recreational boat maintenance or repair on or adjacent to the water

Marinas and Recreational Boating Category Links:

- Assessment, Siting, and Design
  - Marina Flushing
  - Habitat Assessment
  - Water Quality Assessment
  - Shoreline Stabilization
  - Storm Water Runoff
  - Fueling Station Design
  - Sewage Facilities
  - Waste Management Facilities
- Operation and Maintenance
  - Solid Waste Control
  - Fish Waste Control
  - Liquid Material Control
  - Petroleum Control
  - Boat Cleaning and Maintenance
  - Maintenance of Sewage Facilities
  - Boat Operation
- Education/Outreach
  - Public Education/Outreach
The eight assessment, siting, and design management measures for marinas and recreational boating are as follows:

- **4.1A. Assessment, Siting, and Design—Marina Flushing**, which provides for maximum flushing and circulation of surface waters through marina siting and designs. These practices can reduce the potential for water stagnation, maintain biological productivity, and reduce the potential for toxic accumulation in bottom sediment.

- **4.1B. Assessment, Siting, and Design—Habitat Assessment**, which involves siting and designing marinas to protect against adverse impacts on fish and shellfish, aquatic vegetation, and important local-, State-, or federal-designated habitat areas.

- **4.1C. Assessment, Siting, and Design—Water Quality Assessment**, which considers impacts on water quality in siting and designing new and expanding marinas.

- **4.1D. Assessment, Siting, and Design—Shoreline Stabilization**, where shoreline erosion is a pollution problem.

- **4.1E. Assessment, Siting, and Design—Storm Water Runoff**, which involves implementing runoff control strategies to remove at least 80 percent of suspended solids from storm water runoff coming from boat maintenance areas (some boat yards may conform to this provision through NPDES permits).

- **4.1F. Assessment, Siting, and Design—Fueling Station Design**, which requires that fueling stations be located and designed to contain accidental fuel spills in a limited area, and that fuel containment equipment and spill contingency plans be provided to ensure quick spill response.

- **4.1G. Assessment, Siting, and Design—Sewage Facilities**, which requires that pumpout, pump station, and restroom facilities be installed at new and expanding marinas where needed to prevent sewage discharges directly to State waters.

- **4.1H. Assessment, Siting, and Design—Waste Management Facilities**, which requires that facilities be installed at new and expanding marinas where needed for the proper recycling or disposal of solid wastes (e.g., oil filters, lead acid batteries, used absorbent pads, spent zinc anodes, and fish waste as applicable) and liquid materials (e.g., fuel, oil, solvents, antifreeze, and paints).

The seven operation and maintenance management measures for marinas and recreational boating are as follows:

- **4.2A. Operation and Maintenance—Solid Waste Control**, which involves properly disposing of solid wastes produced by the operation, cleaning, maintenance, and repair of boats to limit entry of these wastes to surface waters.

- **4.2B. Operation and Maintenance—Fish Waste Control**, which promotes sound fish waste management, where fish waste is a NPS problem, through a combination of fish cleaning restrictions, education, and proper disposal.

- **4.2C. Operation and Maintenance—Liquid Material Control**, which requires provision and maintenance of the appropriate storage, transfer, containment, and disposal facilities for liquid materials commonly used in boat maintenance, as well as encouraging the recycling of these materials.
4.2D. Operation and Maintenance—Petroleum Control is aimed at reducing the amount of fuel and oil that leaks from fuel tanks and tank air vents during the refueling and operation of boats.

4.2E. Operation and Maintenance—Boat Cleaning and Maintenance, which requires minimization of the use of potentially harmful hull cleaners and bottom paints and prohibiting discharges of these substances to State waters.

4.2F. Operation and Maintenance—Maintenance of Sewage Facilities, which involves maintaining pumpout facilities in operational condition and encouraging their use so as to prevent and control untreated sewage discharges to surface waters.

4.2G. Operation and Maintenance—Boat Operation, which involves prevention of turbidity and physical destruction of shallow-water habitat resulting from boat wakes and propwash.

The education/outreach management measure for marinas and recreational boating, 4.3A Education/Outreach—Public Education, requires that public education, outreach, and training programs be instituted to prevent and control improper disposal of pollutants into State waters.

2.4.1.1 Background

The following fact sheets provide information on management measures that can be used to reduce NPS pollution from marinas and recreational boating activities. The guidance is intended to provide technical assistance to state program managers and others on the best practicable means of reducing NPS pollution of surface waters from marinas and recreational boating.

The guidance can assist marina managers in identifying possible sources of NPS pollution and it offers potential solutions. Finding a solution to NPS pollution problems at a marina requires taking into account the site-specific factors that together compose the setting of a marina. The management practices presented in the following fact sheets are recommended based on their successful application at many marinas. Their applicability to any particular marina or situation, however, must be determined based on site-specific factors. The applicability of the individual management practices and combinations of management practices should be considered within the overall context of the location, environment, design, and needs of the marina. Marina managers should make informed decisions, based on the circumstances at their particular marina, as to whether the management practices in this guidance or others would be most effective for controlling NPS pollution.

2.4.1.2 General Marina-Related Programs and Information Sources

- Boating Clean and Green Campaign (http://www.coastal.ca.gov/ccbn/ccbnindx.html): This program provides education and outreach to promote environmentally sound boating practices for marine businesses and boaters in California. The Web site includes tips on clean boating, information on California water quality programs, listings of oil disposal sites, and links to other boating sites.

- California Clean Boating Network (http://www.coastal.ca.gov/ccbn/ccbnhomenew.html): The California Clean Boating Network is collaboration of government, environmental, business, boating, and academic organizations working toward clean boating education in California. The Web site contains information on the organization’s publication, Changing Tides, and a variety of projects geared toward public education and the promotion of green boating practices.
2.4.1.3 Information on Watersheds

- **Orange County, Watersheds and Coastal Resources Division** (http://www.ocwatersheds.com): This Web site provides detailed information on the watersheds of Orange County.

- **The South Coast Watershed Environmental Education Center, Orange County**, showcases and demonstrates management practices for watershed management and water conservation (Telephone: 949-643-1600).

2.4.1.4 References

2.4.2 Management Measure 4.1A
Assessment, Siting, and Design
Marina Flushing

Management Measure
Site and design new and expanding marinas such that tides and/or currents will aid in flushing the site or renew its water regularly.

2.4.2.1 Management Practices
New or expanding marinas should be designed such that the natural circulation of water from tidal action is not restricted. Ensure that the bottom of the Marina and entrance channels are not deeper than adjacent navigable channels to help keep the bottom of the Marina basin from becoming a pollutant trap, leading to low dissolved oxygen levels.

Consider alternatives to a single-entrance design in poorly flushed water bodies to enhance flushing, for example:

- An open design instead of a semi-enclosed design in a naturally protected location
- Wave attenuators instead of fixed breakwaters where they will provide sufficient protection

New marinas should be designed with as few enclosed water sections or separated basins as possible to promote circulation within the entire basin. Small side basins off the main basin may not flush nearly as well as a large single basin. Consider the value of entrance channels in promoting flushing when designing or reconfiguring a Marina. Two entrances at opposite ends of a Marina can promote flow-through currents.

Use mechanical aerators to improve flushing and water quality where basin and entrance channel configuration cannot provide adequate flushing. Place them in basin corners or other poorly flushed areas.

2.4.2.2 Information Resource
California Department of Boating and Waterways, Layout, Design and Construction Handbook for Small Craft Boat Launching Facilities (http://dbw.ca.gov/PDF/Lramps.pdf): This document describes both mandatory and recommended design criteria for boat launching facilities.

2.4.2.3 References
2.4.3 Management Measure 4.1B
Assessment, Siting, and Design
Habitat Assessment

Management Measure

Site and design new and expanding marinas to protect against adverse effects on shellfish resources, wetlands, submerged aquatic vegetation, or other important riparian and aquatic habitat areas as designated by local, State, or federal governments.

2.4.3.1 Programs
The Marine Region, part of the California Department of Fish and Game, is responsible for protecting and managing California’s marine resources. It was created to improve marine resource management through law enforcement, fisheries and habitat programs, environmental review, and water quality monitoring. The Marine Region has adopted an ecosystem approach that incorporates the values of biological communities and habitats as well as the public, while protecting the health of the marine environment. http://www.dfg.ca.gov/mrd/aboutus.htm.

The California Ocean and Coastal Environmental Access Network (CalOCEAN) is a Web-based ocean resource information system for the State of California. It is designed to provide access to ocean and coastal data and information from a wide variety of sources on biological, physical, and legal information for resource managers, educators, students, and the general public. The data includes, or will include, an inventory of water quality monitoring projects, coastal habitat types and locations, marine managed areas, and wetlands and fisheries information. http://ceres.ca.gov/ocean/.

The Marine Life Inventory, by the California Coastal Commission, Department of Fish and Game, is a program for high school students and teachers to participate in ocean sampling while monitoring water quality (Telephone: 949-640-9956).

2.4.3.2 Management Practices
This management measure involves conducting habitat surveys and characterizing the marina site prior to construction. Critical and unique areas should be inventoried, such as shellfish beds and submerged aquatic vegetation. Areas that provide critical habitat functions, such as riparian areas, spawning areas, nursery areas and feeding areas should be identified so that appropriate measures can be taken to minimize their disturbance. Rapid bioassessment techniques provide a cost-effective way to inventory aquatic resources. Established bioassessment protocols use sampled invertebrate and fish communities as indicators of ecosystem health.

If possible, alternative sites should be considered that could minimize disturbance to sensitive areas. For example, waterfront areas that are already developed could be used for new marinas, or existing marinas could be expanded. If this is not a viable alternative, consider dry stack storage, in which boats are stored on vertical stands, minimizing disturbance, leakage, and pollution from maintenance operations. In addition, a good way to compensate for potential habitat loss is to create or expand habitats within the marina. Rough surfaces such as docks, piers, piles, and floats provide a good substrate for attachment of bivalves and other aquatic organisms.
2.4.3.3 Information Resources


2.4.3.4 References

2.4.4 Management Measure 4.1C
Assessment, Siting, and Design
Water Quality Assessment

Management Measure

1. Assess water quality as a part of the siting and design of new and expanding marinas to establish baseline water quality conditions or trends.

2. Assess water quality at existing marinas to establish baseline water quality conditions.

2.4.4.1 Programs

The San Diego BayKeeper Citizen Monitoring Program trains the public to monitor local waters. BayKeeper works with regulatory agencies, municipalities, academic institutions, businesses and volunteer groups (http://www.sdbaykeeper.org/programs/ctznwater.htm).


The Marine Life Inventory, by the California Coastal Commission, is a program for high school students and teachers to participate in ocean sampling while monitoring water quality (Telephone: 949-640-9956).

The Orange County Marine Life Refuge Project is a community watch volunteer program and a water quality monitoring program to determine the effects of urban runoff. Volunteers of at least high school age are trained in data collection and interpretation (http://www.ocparks.com/tidepools/MLRproject.htm).

The Los Angeles County Ocean Water Monitoring Program provides Web-based beach and rain advisories for Los Angeles County (http://www.lapublichealth.org/beach/).

The State Water Resources Control Board (SWRCB) sponsors the Clean Water Team Citizen Monitoring Program as part of California’s NPS Program http://www.swrcb.ca.gov/nps/)

The City of Santa Barbara Clean Water Program conducts storm water sampling, and ocean and creek monitoring, and supplies information on opportunities for citizen involvement (http://www.countyofsb.org/project_cleanwater/).

The Morro Bay Volunteer Monitoring Program provides citizen monitoring opportunities in Morro Bay estuary waters (http://www.mbnep.org/volunt.htm).

The Monterey Bay Sanctuary Citizen Watershed Monitoring Network is a network of citizens who comprehensively monitor the health of the sanctuary (http://www.mbnms.nos.noaa.gov/monitoringnetwork/welcome.html).

The Southern California Marine Institute’s Environmental Monitoring Program educates students in grades 5–12 on marine environmental issues and water quality monitoring in southern California. The
goal of the program is to educate young people about natural resources and to allow them to become directly involved in monitoring their environment (http://www-bcf.usc.edu/~scmi/Sites/genbroch.html).

The Land Conservancy of San Luis Obispo is implementing a volunteer water quality monitoring program in the county (Telephone: 805-544-9096).

The Coastal Water Quality Monitoring Inventory is a database with information on California's Coastal Water Quality Monitoring Programs. Major water quality monitoring programs along the California coast and its bays are listed, along with details such as the water quality measurements made, locations, frequency, quality assurance information, and contact information (http://www.sfei.org/camp/).

2.4.4.2 Management Practices
Water quality assessments can be conducted through a water quality monitoring program that includes pre-development, construction, and post-development phases to assess the water quality impacts of a marina. Effective assessments can also be accomplished through numerical modeling that includes pre-development and post-construction model applications.

Prior to construction, the current water quality conditions should be assessed. Acceptable water quality data may already have been collected by the U.S. Geological Survey, the U.S. Army Corps of Engineers, State and local agencies or local universities. If new data are required, there are a few ways to collect information when resources are limited:

- Visual inspections of water quality might suffice. Keeping an eye out for oil sheens, trash, and sediment buildup on aquatic plants can be a simple way to track water quality.
- Use rapid bioassessment techniques to monitor water quality. Aquatic insects and grasses can be surveyed quickly and give a good visual idea of how clean the water is.
- Establish a volunteer monitoring program. Enlist the help and environmental enthusiasm of slip renters and their kids. Its good for the marina and the volunteers learn a lot!

As an alternative to a comprehensive monitoring program, water dynamics in a marina basin can be modeled. It is important to keep in mind that all modeling applications require some field data for calibration, and a cost-effective approach would be a combination of both water quality monitoring and numerical modeling. These models can be used to investigate alternative designs and their predicted impact on water quality.

2.4.4.3 Information Resources

Water Quality Monitoring

USEPA, Monitoring and Assessing Water Quality (http://www.epa.gov/owow/monitoring/): This Web site is a repository of technical guidance and information on various water quality assessment techniques. Guidance documents on biological assessment and volunteer monitoring are included.

Watershed Planning

California Coastal Commission, California's Critical Coastal Areas (CCA) Program (http://www.coastal.ca.gov/nps/cca-nps.html): The CCA Program encourages collaboration among local
stakeholders and government agencies to better identify coastal-zone watershed areas in critical need of protection from polluted runoff.

**Bioassessment**

**USEPA, Estuaries and Near Coastal Areas Bioassessment and Biocriteria Guidance**

**2.4.4.4 Case Study**

*Clean Water Team.* The Clean Water Team (CWT) is the citizen monitoring program of the California SWRCB. Regional CWT Citizen Monitoring Coordinators provide technical assistance, training, data management consultation, outreach, and education to citizen monitoring organizations. Citizen monitoring activities include collecting water quality data, evaluating fish habitat, counting birds, or making visual observations of water health. Monitoring activities are available for school children, youth groups, landowners, and community organizations (http://www.swrcb.ca.gov/nps/mission.html).

**2.4.4.5 References**


2.4.5 Management Measure 4.1D
Assessment, Siting, and Design
Shoreline Stabilization

Management Measure

Where streambank or shoreline erosion is a NPS pollution problem, streambanks/shorelines should be stabilized (when determining whether streambank/shoreline erosion is a NPS problem, assess natural erosion rates and the dynamic equilibrium of the streambank/shoreline). The use of vegetative stabilization methods is preferred over the use of structural stabilization methods, if appropriate considering the climate, severity of erosion, offshore bathymetry, and/or the potential adverse impact on other streambanks or shorelines and offshore areas.

2.4.5.1 Programs

Through its Beach Erosion Control Program, the California Department of Boating and Waterways acts as shore protection advisor and plans, designs, and constructs erosion control structures when funds are available. The goals of the program are cosponsoring beach erosion control projects with local and federal agencies, improving present knowledge of oceanic forces, beach erosion and shoreline conditions, and preventing future erosion (http://www.dbw.ca.gov/beach.htm).

2.4.5.2 Management Practices

Shoreline stabilization can be accomplished using either vegetative or structural stabilization techniques. When possible, vegetative stabilization is preferable and often more aesthetically pleasing. Use vegetative plantings, wetlands, beaches, and natural shorelines where space allows.

If structural stabilization is required, riprap revetment is preferable to a solid vertical bulkhead. This is because riprap allows for colonies of aquatic animals and plants and absorbs wave energy better than bulkheads.

Shorelines can be protected from wave energy with structural features such as vertical bulkheads in areas where reflected waves will not endanger shorelines or habitats.

At boat ramps, retain natural shoreline features to the extent feasible and protect disturbed areas from erosion.

2.4.5.3 Information Resources

City of Newport News, Shoreline Erosion Control Informational Brochure (http://www.newport-news.va.us/plan/shoreline.pdf): This four-page brochure provides an overview of various structural and non-structural shoreline stabilization and erosion control practices, complete with photographs, a discussion of environmental impacts, and cost information.

some prior experience with civil engineering. It outlines various affordable shoreline stabilization techniques.


This Web site is a compilation of user-friendly fact sheets that describe and illustrate a number of structural and nonstructural shoreline stabilization practices. The site also links to technical documents, case studies, and useful databases.

### 2.4.5.4 References

2.4.6 Management Measure 4.1E
Assessment, Siting, and Design
Storm Water Runoff

Management Measure

Implement effective runoff control strategies, which include the use of pollution prevention activities and the proper design of marinas and boat maintenance areas (including parking areas). Reduce the average annual loadings of total suspended solids (TSS) in runoff from these areas to meet water quality objectives.

2.4.6.1 Programs

The Marin County Storm Water Pollution Prevention Program produces publications and Web-based information about used oil, hazardous waste, recycling, storm water, and other water quality issues (http://www.mcstoppp.org/).

The LA County Department of Public Works runs a Storm Water Program that provides Web-based information on used oil, solid waste, storm water runoff, recycling, storm drain stenciling and hazardous waste (http://www.ladpw.org/epd/).

The Orange County Watersheds and Coastal Resources Division publishes information on storm water programs and prevention. The Web site for their water pollution hotline provides instructions on reporting a storm drain or water pollution problem, and on the disposal of hazardous wastes (http://www.ocwatersheds.com/WQHotline/wqh_introduction.asp).

Santa Monica Bay’s Storm Water Program provides storm water tips, a contact number for reporting illegal discharges into storm drains, and links for volunteer opportunities (http://www.ci.santa-monica.ca.us/environment/baytips.htm).

The City of Dana Point, Clean Beaches, Clean Oceans provides a public awareness program on the causes of pollution and solutions. It is expanding a catch basin filter installation and maintenance program, as well as educating owners on runoff, recycling, household waste, and grease prevention in sewers (Telephone: 949-248-3588).

The Clean Marina and In-Water Hull Cleaner Programs were created by the Santa Monica Bay Restoration Foundation. They consist of an in-water hull cleaning certification program and a clean marina pilot program. The goals of the programs are to raise awareness regarding the effects that certain boating activities have on water quality, promote management practices and less-toxic products, and promote “green” businesses. Contact Joel Hanson at the Santa Monica Bay Restoration Foundation (Telephone: 213-576-6648).

The Santa Clara Valley Urban Runoff Pollution Prevention Program provides a toll-free phone number where callers can obtain information about urban runoff issues (Telephone: 1-800-794-2482; Web site: http://www.scvurppp-w2k.com/default.htm).

Kids for Clean Water in Orange County provides education on the prevention of urban runoff (Telephone: 949-497-7128).
2.4.6.2 Management Practices

Structural Practices

Increasing vegetation is an easy way to slow runoff and naturally remove pollutants from storm water. Crushed stone paving, sand filters, wet ponds, grassy swales, and traps can be used to catch solids from runoff, and should be installed in particular between impervious areas and the marina basin. Install lawn and garden buffers along the bulkhead to act as natural filters and add beauty to the facility. Where possible, minimize paved surfaces next to the bulkhead to allow rain to soak into the ground instead of running into the water. Finally, construct or restore wetlands where feasible and practical. Wetlands are great storm water filters they provide wildlife habitat and add a natural character to the marina.

Pollutants can also be captured and filtered out of runoff water with permeable tarps, screens, and filter cloths. Install simple oil traps with absorption pillows and debris filters between the work areas and the bulkhead to protect the water quality. Absorbent pillows and filters collect what sweeping misses, like oils and solvents. Install oil/grit separators to capture petroleum spills and coarse sediment. Finally, use catch basins where storm water flows to the marina basin in large pulses (these should be designed by an engineer).

Good Housekeeping

Do as much maintenance work as possible indoors away from rain and runoff. For outdoor work, provide clearly designated land areas away from the water and insist on their use. Also, perform abrasive blasting and sanding in spray booths or tarp enclosures to prevent the wind from taking debris to the water. Restrict the type and amount of do-it-yourself work done at the marina.

Clean hull maintenance areas immediately after any maintenance to remove debris, and dispose of collected material properly. Debris left behind is exposed to storm water runoff and wind. Sweep or vacuum around hull maintenance areas, roads, parking lots, and driveways frequently. Use vacuum sanders to remove paint from hulls and to collect paint dust and chips. Vacuum sanders can collect as much as 99 percent of the dust.

2.4.6.3 Information Resources

- New York Sea Grant Extension Program, Cornell Cooperative Extension, Stormwater Runoff Best Management Practices for Marinas: A Guide for Operators (http://www.seagrant.sunysb.edu/pages/BMPsForMarinas.htm): This 1998 bulletin describes hull maintenance practices and storm water treatment devices suitable for marinas. Cost estimates, planning and technical considerations, photographs, and drawings are included. The document is available online or can be ordered for $2.00.

- Florida Department of Environmental Protection (DEP), Boatyard Stormwater Management (http://www.dep.state.fl.us/law/Grants/CMP/pdf/BoatyardStormwaterManagementBMP.pdf): This six-page fact sheet, part of the Florida DEP’s Clean Boatyard Manual, describes management practices for controlling storm water at marinas.
2.4.6.4 Case Study

*Ski Run Marina Stormwater Filtration System.* Ski Run Marina is located directly on Lake Tahoe and directly discharged its storm water into the lake. In order to prevent NPS pollution from entering the lake, the marina installed a state-of-the-art storm water filtration system, The Stormwater Management StormFilter®, developed by Stormwater Management, Inc. The Ski Run Marina project used a combination of perlite and zeolite filtration media, which allows the StormFilter® to effectively remove the storm water pollutants that have an adverse impact on Lake Tahoe. (http://www.stormwatermgmt.com/news/press_releases/ski_run_marina.pdf).

2.4.6.5 References

2.4.7 Management Measure 4.1F
Assessment, Siting, and Design
Fueling Station Design

Management Measure
Design existing and proposed fueling stations to allow for spill prevention and for ease in cleanup of spills that may occur.

2.4.7.1 Programs
The Marina Fueling Facilities Project is a component of the California SWRCB’s Underground Storage Tank Program. The program administers guidelines and performs inspections for the design and construction of fuel storage, piping, and dispensing systems in marinas (http://www.swrcb.ca.gov/ust/leak_prevention/marina/).

The California Office of Spill Prevention and Response (OSPR) includes a Marine Safety Branch, which works to protect marine resources by developing and maintaining spill prevention measures and response plans. The OSPR requires that all marine facilities and tank vessels carrying petroleum product as cargo, as well as all nontank vessels over 300 gross tons, have California-approved oil spill contingency plans (http://www.dfg.ca.gov/ospr/organizational/msb/msb.htm).

2.4.7.2 Management Practices

For Boaters
Boaters should keep engines properly tuned for efficient fuel consumption and clean exhaust. Avoid overfilling gas tanks, and listen for splashbacks just in case the shutoff nozzle does not work in time. Always keep an absorbent pad ready in case of spills.

For Marina Owners and Operators
Education and Training: Train employees to give information and direction to customers before they begin fueling. Don’t take it for granted that boaters know the correct fueling procedures. Install easy-to-read signs on the fuel dock that explain proper fueling, spill prevention, and spill reporting procedures, especially at self-serve facilities.

Site Design
Locate and design boat fueling stations so that spills can be contained, such as with a floating boom, and cleaned up easily. This usually means locating them away from clutter in areas where spill cleanup will not cause traffic problems.
Spill Prevention

Remove old-style fuel nozzle triggers that are used to hold the nozzle open. Install automatic shutoff systems on fuel nozzles. They help keep spills small and prevent tanks from overfilling. In addition, use a spill monitoring system that will shut off the main line when a leak is sensed.

Install personal watercraft floats at fuel docks to help drivers stabilize their boats and refuel without spilling.

Regularly inspect, maintain, and replace fuel hoses, pipes, and tanks. A small leak can mean a big spill, so check your system often.

Spill Response

Create an emergency spill response plan for containment and cleanup. Make sure to post readable directions for spill response, because in an emergency situation it is important to know exactly what to do. Have spill containment equipment storage, such as a locker attached to the fuel dock, easily accessible and clearly marked. Be prepared for over-spill and excess fuels—keep absorbent pads on hand. If there is an oil spill, call the Coast Guard (Telephone: 1-800-424-8802).

2.4.7.3 Information Resources

- Virginia Clean Marina Guidebook, Emergency Planning (http://www.vims.edu/adv/vamarina/emergencyplanning.pdf): This chapter outlines important emergency planning procedures applicable to marinas.
- California Department of Fish and Game, Office of Spill Prevention and Response, Oil Spill Reporting Procedures (http://www.dfg.ca.gov/ospr/misc/reportaspill.html): This Web site provides basic reporting and contact information.

2.4.7.4 Case Study

Elliot Bay Marina Fueling Station. Elliott Bay Marina in Seattle, Washington, has implemented a number of management procedures, including fueling station design and petroleum control. The marina fuel dock is equipped with double-walled tanks and fuel lines, as well as monitors, sensors, and automatic shutoff in case a leak is detected. The marina keeps oil booms, spill containment kits, and an aluminum pontoon boat on hand for spill response. Boaters are also asked to sign a slip agreement in which they promise to follow the marina’s environmental rules (http://www.elliottbaymarina.net/history.htm).

2.4.7.5 References

National Clean Boating Campaign. Fuelage and Bilge Care Fact Sheet. (http://cleanboating.org/research/boat3a.html)

2.4.8 Management Measure 4.1G
Assessment, Siting, and Design
Sewage Facilities

Management Measure

Install pumpout, dump station, and restroom facilities where needed at new and expanding and existing marinas to reduce the release of sewage to surface waters. Design these facilities to allow ease of access and post signage to promote use by the boating public.

2.4.8.1 Programs

The Clean Vessel Act of 1992 Pumpout Grant Program, established by Congress, is administered by the California Department of Boating and Waterways. The Clean Vessel Act grant funds are available to the public and private sector. Grant recipients receive reimbursement for up to 75 percent of the cost of installing or renovating equipment for sewage pumpout facilities (http://dbw.ca.gov/pumpout.htm).

The California Department of Boating and Waterways provides educational resources and guidance on vessel pumpout facilities, California law governing the discharge of sewage and management practices (http://dbw.ca.gov/PubsAndReports.htm).

2.4.8.2 Management Practices

For Marina Owners and Operators

Restroom Facilities: Marina owners or operators should ensure that there are clean, conveniently located restroom facilities available for those who use the marina, and should encourage their use by customers before casting off.

Onshore Sewage Collection Systems: Onshore sewage collection systems should be installed for slip renters and visiting boats, and a clearly marked sign should indicate their presence to all visitors. Pumpout services should be provided at convenient times and for a reasonable cost, and stations should be kept clean. Collection systems include the following:

- Fixed-Point Systems: Pumpout facilities located at one or more central locations
- Dump Stations for Portable Toilets
- Portable/Mobile Systems: Pumpout facilities that can be moved to the location where a boat is docked

No Discharge Zones: Consider declaring the marina a No Discharge Zone if it is not already in a federal or State-designated No Discharge Zone. The following site provides a list of federal No Discharge Zones: http://www.epa.gov/owow/oceans/regulatory/vessel_sewage/vsdnozone.html.

For Boaters

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Boaters should always use onshore restrooms when their boats are docked, particularly if the boat does not have a toilet. If planning a boat trip for three or more hours, plan for onshore restroom stops while buying fuel or eating at waterfront restaurants. A portable toilet can be taken onboard, and dumped at a shoreside station or at home. It is illegal to dump any untreated sewage into any inland lake, river, or coastal water inside the 3-mile limit. Fats, solvents, oil, emulsifiers, paints, poisons, phosphates, disposable diapers, and sanitary napkins should be kept out of toilets. In addition, pets should be taken to a marina’s posted pet walk area and waste disposed of properly.

If the boat has a Marine Sanitation Device (MSD) type 1 or 2, which pretreats sewage before it is discharged overboard, by law it must be certified by the U.S. Coast Guard. To keep the MSD working properly, follow the manufacturer's suggested maintenance program. Clearly post MSD use instructions near the toilet. If your MSD uses a biodegradable disinfectant, keep the liquid container full. For sanitation systems that require pretreatment chemicals, use chlorine- and formaldehyde-free products. To help prevent clogging, use fast-dissolving marine toilet tissue made for MSD use. When in “no discharge” waters, lock or secure the toilet closed so it cannot discharge overboard.

If your boat has an MSD type 3 with a holding tank, use a pumpout facility at the end of each boating day. They are fast, clean, easy to use, and inexpensive. Consider contracting with a mobile pumpout service to empty your tank while in the slip. If your boat has a y-valve and through hull, always keep them locked closed when inside coastal waters, in bays, in any inland river or lake where dumping untreated sewage is illegal. Opening a y-valve and through-hull is legal only in ocean waters 3 miles or further from shore. The best solution is to remove y-valves and through-hulls so no sewage can go overboard. Use only environmentally compatible holding tank deodorants. To help prevent clogging, use fast dissolving marine toilet tissue made for MSD use.

To find the nearest pumpout service, consult National Oceanic and Atmospheric Administration (NOAA) charts, cruising guides, boating almanacs, or local pumpout maps, or call the National Hotline (Telephone: 1-800-ASK-FISH). When cruising, look for the national pumpout logo at boating facilities to find a pumpout service. If pumping out is self-service, ask a marina staff member for instructions on how to operate the pumpout equipment. Be sure to turn the machine off before leaving and wash your hands after each use.

Encourage the installation of more onshore pumpouts and dump stations by letting marina owners know of the need for local facilities. Report any malfunctioning pumpouts or dump stations by calling the National Hotline (Telephone: 1-800-ASK-FISH).

### 2.4.8.3 Information Resources

- **U.S. Coast Guard, Marine Sanitation Devices (MSDs)**

- **USEPA, Vessel Sewage Discharge Program**

- **California Coastal Commission, Used Oil and Sewage Related Services**
  [http://www.coastal.ca.gov/ccb/E/ccbndx.html](http://www.coastal.ca.gov/ccb/E/ccbndx.html): This Web site provides information on marina-based services by county and mobile environmental services for boaters.
• San Francisco Estuary Project, MSDs and Pumpout Stations
  (http://www.abag.ca.gov/bayarea/sfep/programs/boated/msds.html): This fact sheets describes the importance of properly disposing of sewage and tips for following management practices.

• California Department of Boating and Waterways, Vessel Pumpout Locations
  (http://dbw.ca.gov/pump24/html/index.htm): This Web site provides the names and phone numbers of marinas with vessel pumpout facilities, which can be sorted by name, city, or region. Regional maps are also available online.

• California Department of Boating and Waterways, Shipshape Sanitation
  (http://dbw.ca.gov/Pubs/Sanitation/index.htm): This fact sheet explains the California laws regarding vessel sewage discharge, and the importance of proper disposal.

• California Department of Boating and Waterways, Sewage Holding Tank Systems for Recreational Boats
  (http://dbw.ca.gov/PUMP.HTM): This fact sheet describes California law on sewage holding tanks, and includes information on system design, equipment selection, installation and maintenance.

• U.S. Coast Guard, Federal Marine Sanitation Device Regulations
  (http://dbw.ca.gov/Pubs/FedMSD/index.htm): This fact sheet describes federal regulations and includes a list of no discharge areas in California.

2.4.8.4 Case Study

Oak Harbor Marina Floating Restroom and Barge. Oak Harbor Marina in Washington is a city-owned, recreational boating facility. The marina complies with the marina management measures for sewage facility and maintenance of sewage facilities, as well as a number of other management measures. The facility purchased a floating restroom barge, which has both a pumpout and a dump station, to service the guest docking area. In 1995, a combined total of 1,700 pumpouts were done. An estimated total of 40,000 gallons of boat sewage was collected from the barge and fuel dock, an average of 23.5 gallons per boat. (http://www.p2pays.org/ref/04/03708/text/ch18.html).

2.4.8.5 References

2.4.9 Management Measure 4.1H
Assessment, Siting, and Design
Waste Management Facilities

Management Measure

Install facilities where needed for the proper recycling or disposal of solid wastes (such as oil filters, lead acid batteries, used absorbent pads, spent zinc anodes, and fish waste as applicable) and liquid materials (such as fuel, oil, solvents, antifreeze, and paints) generated by users of marinas and boat maintenance areas. Design these facilities to allow ease of access, post signage to promote use by the boating public, and encourage recycling to the fullest extent possible.

2.4.9.1 Programs
The California Integrated Waste Management Board is responsible for managing California's solid waste stream. The Board develops waste reduction programs, provides public education and outreach, assists local governments and businesses, and fosters market development for recyclable materials. You can obtain information on used oil recycling, including the location of local recycling centers, and other waste management topics on the Board’s Web site: http://www.ciwmb.ca.gov/.

2.4.9.2 Management Practices
Good housekeeping at marinas is a key practice for keeping waste materials out of the water. The following practices can be used by marina operators to improve and encourage the use of waste disposal facilities:

- Encourage marina patrons to avoid doing any hull maintenance while their boats are in the water. Scraped-off paint and debris can be harmful to aquatic life.
- Place trash and recycling receptacles in convenient locations for marina patrons. Let customers know they are there and encourage their use. In addition, provide information on fishing line collection and recycling or disposal. Provide boaters with trash bags so they can collect waste onboard and bring it back to be disposed of properly.
- Require patrons to clean up pet wastes. Provide a specific dog walking area at the marina. Plastic bags provided near the walking area will help keep the marina clean and help customers comply with the rule.
- Install fish cleaning stations at the marina and at boat launch sites. Cleaning stations help keep waters from becoming dumping grounds. In addition, compost fish waste where appropriate and encourage catch and release fishing, which does not kill the fish and produces no fish waste. Encourage boaters to clean fish offshore where the fish are caught and return the waste to the sea (if allowed by the State).

2.4.9.3 Information Resources
- California Department of Fish and Game, Fishing Line Recycling (http://www.dfg.ca.gov/fishing/html/Publications/recycle.html): This Web page provides instructions for recycling fishing lines in California.
• Maryland Clean Marina Initiative, Waste Containment and Disposal
  (http://dnrweb.dnr.state.md.us/download/cleanmarina/8TipSheet-ps.pdf): This fact sheet describes waste management practices for trash, fish waste, and liquid waste.

2.4.9.4 References
2.4.10 Management Measure 4.2A
Operation and Maintenance
Solid Waste Control

**Management Measure**

Properly dispose of solid wastes produced by the operation, cleaning, maintenance, and repair of boats and operation of marinas—and encourage recycling of recyclable materials to the fullest extent possible—to limit entry of solid wastes to surface waters.

2.4.10.1 Programs

The California Coastal Commission’s Boating Clean and Green Program publishes information on oil and sewage-related services (http://www.coastal.ca.gov/ccbn/ccbnindx.html).

San Diego BayKeeper works to detect and report illicit discharges and pollution from boating activities with boat patrols, monitoring, and a pollution hotline (http://www.sdbaykeeper.org/programs/beachcln.htm).

The Los Angeles County Department of Public Works runs a Storm Water Program that provides Web-based information on used oil, solid waste, storm water runoff, recycling, and hazardous waste (http://www.ladpw.org/epd/).

The Ocean Conservation Society conducts Kayak Cleanups of Marina Del Rey in Los Angeles County. These trash and debris cleanups are sponsored by the Ocean Conservation Society in collaboration with COBRA Kayaks and Patagonia Santa Monica, an ongoing series of cleanups of Marina del Rey Harbor (http://www.oceanconservation.org/mdrcleanuptxt.html).

The California Coastal Commission holds the California Coastal Cleanup Day in order to help reduce marine debris along the coast, as well as educate the public on the dangers of dumping marine debris and the potential for environmental damage. The Web site provides information on the annual event, as well as on marine debris and its effects (http://www.coastal.ca.gov/publiced/ccd/ccd.htm).

The Marin County Storm Water Pollution Prevention Program produces publications and Web-based information about used oil, hazardous waste, recycling, storm water, and other water quality issues (http://www.mcstoppp.org/).

The City of Dana Point, Clean Beaches, Clean Oceans provides a public awareness program on the causes of pollution and solutions. It is expanding a catch basin filter installation and maintenance program, as well as educating owners on runoff, recycling, household waste, and grease prevention in sewers (Telephone: 949-248-3588).

Heal The Bay provides Santa Monica Bay’s environmental events calendar, citizen involvement, and beach report (http://www.healthebay.org/).

Generation Earth in Los Angeles County provides Web-based information about the solid waste problem in Los Angeles and citizen involvement opportunities (http://www.generationearth.com/).
2.4.10.2 Management Practices

For Marina Owners and Operators

Provide easily accessible recycling facilities for glass, newspapers, aluminum, plastics, batteries, and numerous, well-marked trash receptacles. Recycling can reduce the amount of dumpster trash, which lowers waste hauling fees. Train staff to inform patrons of trash disposal practices and to pick up any trash they see lying about. Provide boaters with trash bags imprinted with the marina’s logo to demonstrate a commitment to pollution prevention.

Encourage staff and boaters to follow these principles for cleaning activities:

- Use less-toxic or less-caustic materials and use less of them.
- Purchase frequently used materials in bulk to minimize waste.
- Buy products that come in reusable containers and have minimal packaging.
- Advise customers to buy only what is needed for immediate use to avoid throwing away what is left over.
- Share leftover products with others who need them.
- Avoid the use or sale of anything described as being “disposable” and encourage the use of long-life products.

For Boaters

Conduct hull work indoors or under cover where possible, and discourage dockside sanding and painting over the water. At the very least, stretch a tarp between the side of the boat and the dock to catch any falling debris. Use drop cloths or filter cloths beneath the hull to collect sanding dust and paint drops. Empty the cloths into a trash container frequently, and do not leave them dirty overnight. Use only non-abrasive underwater hull cleaning techniques to prevent excessive paint discharge. Dry storage reduces the need for antifouling paints and saves money.

Dispose of paints, batteries, antifreeze, cleaning products, oil, oil filters, and other hazardous wastes at a hazardous waste collection facility. Call Earth’s 911 to find a location nearby (1-800-CLEAN-UP). Recycle paints, batteries, oil, oil filters, and antifreeze.

Keep all trash on board. Never throw cigarette butts, fishing line, or any other garbage into the ocean. Take advantage of shoreside facilities to recycle plastic, glass, metal, and paper. Reduce the potential for litter by removing unnecessary packages and wrappings, and bringing reusable containers to the boat. Have several litter bags onboard and discard full ones at the marina dumpster or at home. When trash accidentally falls overboard, go back and get it.

2.4.10.3 Information Resources

- Florida Department of Environmental Protection, Solid Waste Management (http://www.dep.state.fl.us/law/Grants/CMP/pdf/SolidWasteManagementBMP.pdf): This fact sheet, part of the Florida Department of Environmental Protection’s Clean Boatyard Manual, describes ways to prevent pollution from solid waste.

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2.4.10.4 References

2.4.11 Management Measure 4.2B
Operation and Maintenance
Fish Waste Control

Promote sound fish waste management through a combination of fish-cleaning restrictions, public education, and proper disposal of fish waste.

2.4.11.1 Management Practices
Use a fish cleaning station, which usually has a waste grinder, running water, and a large surface to work on. Alternatively, clean fish as they are caught offshore and toss fish waste only in open unrestricted water or at sea (where the State allows it), rather than in the marina basin where circulation and flushing are more limited and the fish waste could create a water quality and odor problem.

Recycle fish parts by composting them with peat moss, or burying them in a garden to be used as fertilizer. Fish parts can also be frozen and re-used as bait or chum on another next fishing trip. When no other option exists, bag the fish parts and place the bag in the trash.

Finally, avoid releasing bait either dead or alive into the water. This can introduce foreign species to fresh water lakes. You might not be releasing just the bait, but something that it is infected with.

2.4.11.2 Information Resources
Maryland Clean Marina Initiative, Waste Containment and Disposal (http://dnrweb.dnr.state.md.us/download/cleanmarina/8TipShee-ps.pdf): This fact sheet describes waste management practices for trash, fish waste, and liquid waste.

2.4.11.3 Case Study
Marin County–Petaluma River Black Point Boat Launching Facility. In 2003, the Department of Boating and Waterways awarded the County of Marin $80,000 for a proposed $782,000 project to replace the boat launching facility at Black Point in Novato, on the Petaluma River. The new boat launching facility will include a fish cleaning station. Additional measures incorporated into the plan include new restrooms and a boat wash-down area (http://www.dbw.ca.gov/bwcm3-13-03.htm).

2.4.11.4 References
2.4.12 Management Measure 4.2C
Operation and Maintenance
Liquid Material Control

Management Measure

Provide and maintain appropriate storage, transfer, containment, and disposal facilities for liquid materials—such as fuel, oil, solvents, antifreeze, and paints—and encourage recycling of these materials to the fullest extent possible.

2.4.12.1 Programs

The Marin County Storm Water Pollution Prevention Program produces publications and Web-based information about used oil, hazardous waste, recycling, storm water, and other water quality issues (http://www.mctopp.org/).

The Los Angeles County Department of Public Works runs a Storm Water Program that provides Web-based information on used oil, solid waste, storm water runoff, recycling, and hazardous waste (http://www.ladpw.org/epd/).


The California Coastal Commission’s Boating Clean and Green Program publishes information on oil and sewage-related services (http://www.coastal.ca.gov/ccbn/ccbndx.htm).

The California Integrated Waste Management Board’s Used Oil Recycling Program develops and promotes alternatives to the illegal disposal of used oil by establishing a statewide network of collection opportunities and undertaking outreach efforts to inform and motivate the public to recycle used oil (http://www.ciwmb.ca.gov/UsedOil/). The Board’s Household Hazardous Waste Program aims to provide the public with convenient collection locations for used oil and other types of household hazardous waste, increase the demand for new products made from oil and household hazardous waste, and provide grants to local governments, nonprofit organizations, and for research and demonstration projects (http://www.ciwmb.ca.gov/HHW/).

2.4.12.2 Management Practices

For Marina Owners and Operators

Storage: Store minimal quantities of hazardous materials. Reduce waste by buying only as much as is needed. Liquid materials should be carefully stored under cover and on an impervious surface. Locate storage and disposal areas for liquid materials in or near repair and maintenance areas for ease of access but away from flood areas and fire hazards, and protect them from rain with a cover and berms or secondary containment.
Disposal: Provide clearly labeled, separate containers for the disposal of waste oils, fuels, and other liquid wastes. Keeping them separate minimizes the chance of combining dangerous chemicals and makes them easier to recycle.

Spill prevention: Prepare a hazardous material spill recovery plan and update it as new types of materials are acquired or other changes are necessary. Keep adequate spill response equipment where liquid materials are stored and used. Change engine oil using non-spill vacuum-type systems, and use the same equipment to suction oily water from bilges.

For Boaters

Recycle liquid materials where possible, and ask your marina to provide recycling if it does not already do so. Use antifreeze and coolants that are less toxic to the environment. Propylene-glycol-based antifreeze (with a pink color) is less toxic than the blue-green antifreeze. Recycle the blue-green antifreeze if it is used.

Use alternative, less-toxic liquid materials where practical. Minimize the use of solvents or switch to water-soluble choices. Before discarding paint cans, remove the top and let any paint residue dry and harden.

2.4.12.3 Information Resources


- **University of California Cooperative Extension, Marina Pollution Prevention Manual** ([http://nsgd.gso.uri.edu/cuimr/cuimrh95002.pdf](http://nsgd.gso.uri.edu/cuimr/cuimrh95002.pdf)): This manual describes important components of pollution prevention at recreational boating facilities. It covers pollution sources, hazardous waste management, spill response, marina staff procedures and training, San Diego County agency and service contacts, and publications for distribution among marina staff, contractors, and boaters.

2.4.12.4 References

2.4.13 Management Measure 4.2D
Operation and Maintenance
Petroleum Control

Management Measure
Reduce the amount of fuel and oil from boat bilges and fuel tank air vents entering marina and surface waters.

2.4.13.1 Programs
The Los Angeles County Department of Public Works runs a Storm Water Program that provides Web-based information on used oil, solid waste, storm water runoff, recycling, and hazardous waste (http://www.ladpw.org/epd/).

The Santa Monica BayKeeper Program in LA County is conducting a “Fill It, Don’t Spill It” campaign to address the accidental discharge of petroleum at fuel docks (http://www.smbaykeeper.org/smbay/programs/).

The Marin County Storm Water Pollution Prevention Program produces publications and Web-based information about used oil, hazardous waste, recycling, storm water, and other water quality issues (http://www.mcstoppp.org/).


The Lake Tahoe Pollution Prevention Marina Program is focused on promoting environmentally responsible and cost-effective management of used oil. The emphasis is on increasing boater awareness of the impacts of illegally disposed oil, poorly maintained watercraft, bilge water pumped overboard, and on the availability of used oil collection centers (http://www.co.el-dorado.ca.us/emd/solidwaste/marina.html).

The California Coastal Commission’s Boating Clean and Green Campaign administers the Shop Clean and Green Program. Shopping Clean and Green Displays, designed for marina supply shops, provide consumers with free plastic wallet-sized information cards. These cards contain product information and tips for recycling used oil and reducing oil and fuel discharges from boats as well as toll-free numbers for boater information about waste disposal and reporting spills (http://www.coastal.ca.gov/ccbn/ccbnindx.html).

The California Coastal Commission’s Boating Clean and Green Program publishes information on oil and sewage-related services (http://www.coastal.ca.gov/ccbn/ccbnindx.html).

2.4.13.2 Management Practices
To prevent fuel and oil leaks, keep your engine well tuned. Place an oil absorbent pad or pillow under your engine where drips may occur and in the bilge. Check the pads often and dispose of them as hazardous waste at a marina or nearby collection center. Spill-proof your oil changes by using an oil...
change pump to transfer oil to a spill-proof container. Wrap a plastic bag or absorbent pad around the oil filter to prevent oil from spilling into the bilge. Fill fuel tanks slowly and carefully and use absorbent pads or rags to catch drips and spills. Do not top off or overflow the fuel tank, and leave it 5 percent empty to allow fuel to expand as it warms. If there is a spill, do not use soap or emulsifiers to disperse it. That is harmful to the environment, as well as illegal. Rather, notify the marina and the proper authorities.

If the boat has an outboard motor, fill tanks carefully to avoid spilling fuel into the boat and wasting fuel. Mix oil in the fuel according to manufacturer recommendations. Clean any drops off the deck by wiping with an oil absorption pad. Close portable tank fuel vents when the boat is not in use to save fuel from vapor loss, and store fuel only in approved marine containers.

If the boat has a built-in fuel tank on board, install a fuel/air separator in the air vent line from the tank to prevent vent spills. Routinely check for and fix fuel leaks. Use a bilge-oil absorbent pillow and dispose of it before it is fully saturated by recycling it with used oil, or use a bilge-maintenance bioremediation pad with natural oil-eating bacteria, which can last much longer than absorbent pads. If the boat is 26 feet or more in length, it is a legal requirement to display a U.S. Coast Guard oil discharge placard on the boat.

All boaters should avoid pumping any bilge water that is oily or has a sheen. A drip pan should be used under the engine and routine checks performed for oil or fuel leaks. In addition, avoid the use of bilge cleaners that are detergents or emulsifiers. These chemicals dissolve the oil and fuel in the water so both can be pumped overboard into the water. The bilge may be clean, but the water won’t be.

If there is a spill, immediately stop the source, notify the marina for assistance, and call the U.S. Coast Guard (Telephone: 1-800-424-8802). Contain the spill with absorbent pads or booms, and do not apply any detergent or emulsifier to the oil slick. Dispose of absorbent pads with recyclable oil, or wrap them in newspaper and tie them inside a plastic bag for disposal with your home trash.

2.4.13.3 Information Resources

- **Rhode Island Sea Grant, Bilges, Fueling and Spill Response** *(http://seagrant.gso.uri.edu/factsheets/boaterfs/bilge.html):* This is a brief fact sheet with information on bilge pumping, fueling, and spill response.

- **El Dorado County, Lake Tahoe Pollution Prevention Marina Program** *(http://www.co.el-dorado.ca.us/emd/solidwaste/marina.html):* This Web site provides information about a Lake Tahoe program to reduce oil pollution.

- **California Coastal Commission, Used Oil and Sewage Related Services** *(http://www.coastal.ca.gov/ccbn/cbndx.html):* This Web site provides information on marina-based services by county, mobile environmental services for boaters, and used oil collection centers in California.

- **El Dorado Environmental Management Department, Oil Absorbent Pads and Pillow Disposal Sites** *(http://www.co.el-dorado.ca.us/emd/solidwaste/pillow_sites.html):* This is a list of marinas participating in Lake Tahoe’s Pollution Prevention Marina Program by collecting absorbent pads and pillows.

- **Florida Department of Environmental Protection (DEP), Used Oil and Petroleum Management** *(http://www.dep.state.fl.us/law/Grants/CMP/pdf/PetroleumBMP.pdf):* This 14-page fact sheet, part of the Florida DEP’s *Clean Boatyard Manual*, provides guidance for marina owners on proper storage, disposal, spill prevention, and fueling procedures.
• **California Coastal Commission, Oil Pollution Solutions for Boaters: Designing and Implementing Programs to Reduce Hydrocarbon Discharges.** This is a manual for government, businesses and individual owners that provides guidance on reducing oil pollution and developing education and outreach programs. It presents an overview of marine pollution and boating in California, information on services marina operators can provide to reduce pollution, guidance on various types of boats and their operation/maintenance needs, and information on the development of outreach programs. Order from the Boating Clean and Green Campaign (Telephone: 415-904-5200).

• **University of California Cooperative Extension, Marina Pollution Prevention Manual** ([http://nsgd.gso.uri.edu/cuimr/cuimrh95002.pdf](http://nsgd.gso.uri.edu/cuimr/cuimrh95002.pdf)). This manual describes important components of pollution prevention at recreational boating facilities. It covers pollution sources, hazardous waste management, spill response, marina staff procedures and training, San Diego County agency and service contacts, and publications for distribution among marina staff, contractors, and boaters.

• **California Department of Fish and Game, Office of Spill Prevention and Response (OSPR), The Office of Spill Prevention and Response’s Guide to Clean, Green Boating.** This is a 4-inch by 6-inch flip guide to oil spill prevention. It includes information about OSPR, the impacts of oil spills, and pollution prevention tips. It also includes rules of the road, navigation tips, information about boating courses, and a space to write notes. Contact California Boating Clean and Green Campaign (Telephone: 415-904-5200).

### 2.4.13.4 Case Study

**Lake Tahoe Pollution Prevention Marina Program.** The Lake Tahoe Pollution Prevention Marina Program was motivated by a general concern for the ecosystem health in the lake. It promotes responsible management of used oil and increased public and boater awareness. The program focuses on lake ecosystems, the environmental impacts of oil pollution, boater education, and improving the availability of oil collection centers ([http://www.co.el-dorado.ca.us/emd/solidwaste/marina.html](http://www.co.el-dorado.ca.us/emd/solidwaste/marina.html)).
California Coastal Commission, *Oil Pollution Solutions for Boaters: Designing and Implementing Programs to Reduce Hydrocarbon Discharges*. This is a manual for government, businesses and individual owners that provides guidance on reducing oil pollution and developing education and outreach programs. It presents an overview of marine pollution and boating in California, information on services marina operators can provide to reduce pollution, guidance on various types of boats and their operation/maintenance needs, and information on the development of outreach programs. Order from the Boating Clean and Green Campaign (Telephone: 415-904-5200).


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2.4.14 Management Measure 4.2E
Operation and Maintenance
Boat Cleaning and Maintenance

Management Measure

For boats that are in the water, perform (1) topside cleaning and maintenance operations to minimize, to the extent practicable, the release to surface waters of (a) harmful products such as cleaners and solvents and (b) paint; and (2) underwater hull cleaning and maintenance operations to minimize, to the extent practicable, the release of paint and anodes.

2.4.14.1 Programs

The Nontoxic Bottom Paint Demonstration Project by the University of California, Davis, Sea Grant Extension Program in San Diego County provides educational resources and conducts field demonstrations of nontoxic boat bottom paints (http://commserv.ucdavis.edu/cesandiego/seagrant/nontoxicdemo.htm).

The Clean Marina and In-Water Hull Cleaner Programs were created by the Santa Monica Bay Restoration Foundation. They consist of an in-water hull cleaning certification program and a clean marina pilot program. The goals of the programs are to raise awareness regarding the effects that certain boating activities have on water quality, promote management practices and less-toxic products, and promote “green” businesses. Contact Joel Hanson at the Santa Monica Bay Restoration Foundation (Telephone: 213-576-6648).

The California Professional Divers’ Association has established a Professional Divers Training and Certification Program to educate divers on pollution prevention from underwater hull cleaning and other management practices (http://www.prodivers.org/bmpprogram.htm).

2.4.14.2 Management Practices

Boat Cleaning

One way to reduce the potential for pollution is to buy “nontoxic” and “phosphate-free” products. While “biodegradable” products are desirable, they are not necessarily nontoxic. If possible, avoid those that warn “do not get in the eyes” or “always wear gloves,” such bleach, ammonia, lye, or petroleum distillates.

Buy only as much cleaner as you need to avoid having to dispose of leftover cleaning supplies. If you do have leftovers, give them to another boater or start an exchange program at the marina for cleaners, paints, varnishes, and other materials. Always keep caps on bottles while cleaning to prevent spills.

Wash decks and hulls frequently with fresh water, because this will reduce the need for cleaning products. When cleaners are necessary, use them sparingly. While washing, try to avoid washing dirt, paint chips, and solvents into the water by washing boat hulls above the waterline by hand. Clean boat bottoms
ashore, over hard surfaces or over a tarp to contain debris. Whenever feasible, remove boats from the water and clean them where debris can be collected and disposed of in the trash.

Finally, thoroughly wash off your boat if taking it from one body of water to another. This will help minimize the spread of exotic and invasive species.

**Boat Maintenance**

Whenever possible, hull work should be done inside or under cover where rain cannot wash dust, dirt, paint chips, oil, and solvents into the water.

Prevent pollution from engine maintenance by tuning your engine regularly per the manufacturer's recommendation. This helps your engine operate cleanly and more efficiently. Frequently inspect fuel lines for leaks or potential leaks such as cracks and loose connections, and repair them immediately. Frequently wipe the engine to keep it clean. Engine parts should be cleaned on land over a leak-free container, not over the water, with minimal amounts of engine-cleaning solvents.

Change oil and transmission fluid with a spill-proof pump or vacuum tank. Slip a plastic bag over the oil filter before removing it. Wipe up oil drops immediately with an absorbent pad. Keep used oil separate from other wastes and recycle it. Use antifreeze and coolants that are less toxic to the environment. Propylene-glycol-based antifreeze (with a pink color) is less toxic than the blue-green antifreeze. Recycle the blue-green antifreeze if it is used.

Prevent pollution from sanding and painting by doing all hull scraping, sanding, and chemical stripping onshore over a drop cloth to catch all debris. Prepare the surface with dustless sanders to keep you, the air, the ground, and other boats clean. Be sure to use only legal bottom paints, and depending on boat use, consider a hard non-ablative paint that might last longer. If possible, switch to long-lasting and low-toxicity or nontoxic antifouling paints. New environmentally friendly alternative paints are being developed, so ask around for the latest and best. Leave paint cans open to thoroughly dry out before throwing them away.

2.4.14.3 **Information Resources**

- **California Coastal Commission, Clean Green Boat Maintenance** ([http://www.coastal.ca.gov/ccbn/checklist.pdf](http://www.coastal.ca.gov/ccbn/checklist.pdf)): This is a pollution prevention boat maintenance checklist for contractors and the general public.

- **University of California Cooperative Extension, Selecting Underwater and Topside Maintenance Services for Your Boat** ([http://commserv.ucdavis.edu/cesandiego/seagrant/topside.htm](http://commserv.ucdavis.edu/cesandiego/seagrant/topside.htm)): This fact sheet provides guidance on the selection of a professional maintenance service that will follow environmentally sound procedures.

- **University of California Cooperative Extension, Underwater Hull Cleaner’s Best Management Practices** ([http://commserv.ucdavis.edu/cesandiego/seagrant/hullclean.htm](http://commserv.ucdavis.edu/cesandiego/seagrant/hullclean.htm)): This fact sheet is for professionals and describes ways to lower costs as well as to help the environment with management practices that reduce pollution and extend the life of hull paints.

- **University of California Cooperative Extension, Selecting a Hull Paint for Your Boat** ([http://commserv.ucdavis.edu/cesandiego/seagrant/selpaint.htm](http://commserv.ucdavis.edu/cesandiego/seagrant/selpaint.htm)): This fact provides tips on the most environmentally sound practices related to antifouling.

Last Updated July 30, 2004
**Florida Department of Environmental Protection (DEP), Boat Cleaning**
(http://www.dep.state.fl.us/law/Grants/CMP/pdf/BoatCleaningBMP.pdf): This 8-page fact sheet, part of the Florida DEP’s *Clean Boatyard Manual*, describes management practices for cleaning in the water, saltwater rinsing, and pressure cleaning.

**California Department of Boating and Waterways, Boater Alert: Hydrilla**
(http://dbw.ca.gov/Pubs/Hydrilla/Hydrilla.pdf): This fact sheet provides background information on hydrilla, an invasive species, and gives tips on how to avoid spreading this aquatic pest from one waterway to another.

### 2.4.14.4 Case Study

*Innovative Boat Maintenance Facility.* Summerfield Boat Works, Inc., in Broward County, Florida, installed a water recycling system for boat maintenance activities that does not discharge any wastewater. Water used for cleaning is cleaned with ultraviolet technology and reused. The marina reports conservation of 24,000 gallons of water every year (http://www.umich.edu/~nppc/pub/resources/compendia/CSTLpdfs/CSTLmarina.pdf).

### 2.4.14.5 References

2.4.15  Management Measure 4.2F
Operation and Maintenance
Maintenance of Sewage Facilities

Ensure that sewage pumpout facilities are maintained in operational condition and encourage their use.

2.4.15.1 Programs
The Clean Vessel Act of 1992, Pumpout Grant Program, established by Congress, is administered by the California Department of Boating and Waterways. Clean Vessel Act grant funds are available for the public and private sectors. Grant recipients receive reimbursement for up to 75 percent of the cost of installing or renovating equipment for sewage pumpout facilities (http://dbw.ca.gov/pumpout.htm).

2.4.15.2 Management Practices
Regularly inspect and maintain sewage facilities. Small leaks can cause big pollution problems, and non-functioning facilities increase the chance that boaters will discharge into the water. Consider having a contractor regularly repair and maintain the pumpout and dump station if it takes up too much staff time.

Disinfect the suction connection of a pumpout station (stationary or portable) by dipping or spraying it with disinfectant after each use. This practice is primarily for the protection of public health. Ensure that the disinfectant is safely stored such that it is not at risk of being spilled into the water.

Provide dump stations for boaters who use portable toilets to dispose of their waste.

Keep restroom facilities in the marina clean, dry, and pleasant, and locate them where they are convenient to use.

2.4.15.3 References
2.4.16 Management Measure 4.2G
Operation and Maintenance
Boat Operation

Management Measure
Restrict boating activities where necessary to decrease turbidity and physical destruction of shallow-water habitat.

2.4.16.1 Management Practices

For Marina Owners and Operators
Restrict boater traffic in shallow-water areas. Put signs up near sensitive areas of your marina or give boaters maps that indicate where boats should be operated with caution to avoid environmental harm.

Mark seagrass beds and other sensitive areas with signs. Survey these areas annually (since they can grow and expand) to ensure you have them marked correctly.

For Boaters
Respect no-wake zones and speed limits. They are posted to protect the environment and other boaters.

Familiarize yourself with the underwater environment where you will be boating so you can anticipate and avoid sensitive environmental areas, like seagrass beds and coral reefs. Ask the marina or a local conservation organization for maps that show these areas.

Ask marina operators and local authorities to post signs in the water that indicate where boaters should not go to avoid damaging the environment.

2.4.16.2 References
2.4.17 Management Measure 4.3A
Education/Outreach
Public Education/Outreach

Management Measure

Implement educational programs to provide greater understanding of watersheds, and to raise awareness and increase the use of applicable marina and boating management measures and practices where needed to control and prevent adverse impacts on ground and surface waters. Public education, outreach, and training programs should involve applicable user groups and the community (e.g., boaters, boating groups, marina owners and operators, boat maintenance facility operators, waterfront agencies, service providers, live-aboards, environmental groups, and other related groups).

2.4.17.1 Programs

The Save Our Shores Sanctuary Steward Certification Program is a training program for presenting beach cleanup and sanctuary slide programs on the Monterey Bay National Marine Sanctuary (http://www.mbnms.nos.noaa.gov/educate/sospgm.htm).

The Santa Clara Valley Urban Runoff Pollution Prevention Program has a hotline for callers to obtain information about urban runoff issues (Telephone: 1-800-794-2482; Web site: http://www.scvurppw2k.com/default.htm).

The San Francisco Estuary Project's Boater Education Program publishes fact sheets, flyers, and guidance documents on clean boating practices (http://www.abag.ca.gov/bayarea/sfep/programs/boated/).

The Boating Clean and Green Campaign Dockwalkers Program trains boaters and other volunteers to conduct face-to-face boater education on environmentally sound boating practices (http://www.coastal.ca.gov/ccbn/ccbndx.html).

The Santa Monica Bay Restoration Program’s Boater Education Program works to reduce pollution from recreational boating activities through technical assistance and outreach efforts. The program was awarded California Environmental Protection Agency's Program Excellence Award in May 2001 (http://www.santamonicabay.org/site/programs/layout/boater.jsp).

2.4.17.2 Management Practices

Communicate with Boaters

Ensure that management practices are clearly communicated to boaters. Use signs to inform marina patrons of appropriate clean boating practices and establish bulletin boards for environmental messages and forums for sharing leftover paints and varnishes. Hand out pamphlets or flyers, send newsletters, and add inserts to bill mailings with information about how recreational boaters can protect the environment and keep marina waters clean. Organize environmental education meetings, presentations, and demonstrations. For instance, hold clinics on safe fueling and bilge maintenance. Paint signs on storm drains so patrons know that what they toss on the ground is tossed into the water. Place signs in the water...
and label charts to alert boaters about sensitive habitat areas they should avoid. Finally, insert language into facility contracts that promotes the use of clean boating and maintenance practices. Using a contract increases the likelihood that tenants will comply with the marina’s management practices.

**Training and Education of Marina Staff**

Educate and train marina staff to do their jobs in an environmentally conscious manner and to be good role models for marina patrons. Have a clearly written environmental management practices agreement for outside contractors to sign as a precondition to their working on any boat in the marina.

Promote recycling and trash reduction programs. Tell your patrons what they can recycle and where to put recyclables. Provide information on local waste collection and recycling programs.

**Provide Pollution Prevention Resources**

MARPOL is the protocol resulting from the International Convention for the Prevention of Pollution from Ships, initially adopted in 1973 and revised in 1978 (for more information, visit [http://www.londonconvention.org/marpol_73.htm](http://www.londonconvention.org/marpol_73.htm). One of the provisions of the MARPOL protocol requires that boats carrying oil, noxious liquids, and harmful substances in packaged form display pollution prevention placards. These placards should be provided and phosphate-free, nontoxic cleaners and other environmentally friendly products stocked in the marina store.

2.4.17.3 Information Resources

- **Marin County Storm Water Pollution Prevention Program, Boating Clean and Green** ([http://www.mcstoppp.org/consumers.htm](http://www.mcstoppp.org/consumers.htm)): This is Marin County’s guide to environmentally sound boating practices, available by calling the county (Telephone: 415-499-6528).

- **Boating Clean and Green Campaign, An Annotated Catalog of Marina and Recreational Boater Pollution Education Materials** ([http://www.coastal.ca.gov/ccbn/catalognew.html](http://www.coastal.ca.gov/ccbn/catalognew.html)): This is a comprehensive annotated bibliography, available online. It includes audiovisual materials, handbooks and manuals, fact sheets, brochures, posters, stickers, and mailers.

- **Boating Clean and Green Campaign, Materials for Educators** ([http://www.coastal.ca.gov/ccbn/ccbnidx.html](http://www.coastal.ca.gov/ccbn/ccbnidx.html)): A compilation of fact sheets, reports, signs, and brochures for use by anyone conducting an outreach or education effort.

- **Boating Clean and Green Campaign, The Dockwalkers Handbook: A Manual for Participants in Dockwalkers’ Training**. This manual is used as training for the Dockwalkers program. It addresses pollutants and management practices related to oil and fuel, sewage, boat cleaning and maintenance, hazardous and solid waste, marine debris, and gray water. Contact the California Coastal Commission, Boating Clean and Green Campaign (Telephone: 415-904-5200).

- **Maryland Clean Marina Initiative, Clean Boating Lesson Plan** ([http://dnrweb.dnr.state.md.us/download/lessonplan6.pdf](http://dnrweb.dnr.state.md.us/download/lessonplan6.pdf)): This lesson plan includes a speaking plan, overheads, and handouts on petroleum control, vessel sewage, waste containment and disposal, and vessel cleaning and maintenance.

- **California Clean Boating Network, Changing Tide Newsletter** ([http://www.santamonicabay.org/site/library/layout/index.jsp](http://www.santamonicabay.org/site/library/layout/index.jsp)): The newsletter provides...
information on clean boating practices in California, focusing on new trends in clean boating practices and environmental services for boaters.

2.4.17.4 Case Study

Southern California Boater’s Guide. The Santa Monica Bay Restoration Project published the Southern California Boater’s Guide as an educational product for the boating community. It serves as a recreational cruising guide and contains important information on clean boating practices. The guide covers Santa Barbara, Ventura, Los Angeles, Orange, and San Diego County harbors. It promotes clean boating in a fun, attractive, and user-friendly format; focuses on the importance of maintaining a boat in the most environmentally friendly manner possible; and explains the potentially adverse impacts that a poorly maintained boat can have on coastal waters.

The guide has three primary sections: General Boating, Harbors, and Boating Clean and Green. The General Boating section addresses boating safety, communications, navigation, rules and regulations, and vessel equipment requirements, registration, and operation. The Harbors section provides information about each of the region's 15 harbors, including overviews; what to do upon arrival; maps; the locations of waste disposal facilities for used motor oil, sewage, hazardous waste, and trash; and finally, a host of recreational opportunities (e.g., boardwalks, restaurants, shopping districts, fun-zones, beach rentals). The Boating Clean and Green section discusses the types of boating-related activities that could pollute marina and coastal waters, and how to prevent such pollution. Contact Stephanie McDonald of the Santa Monica Bay Restoration Project (Telephone: 323-266-7667; E-mail: smbrp@earthlink.net; Web site: http://www.santamonicabay.org/site/library/layout/index.jsp).

2.4.17.5 References

2.5 Hydromodification

2.5.1 Introduction

2.5.1.1 Background
The State Water Resources Control Board (SWRCB), California Coastal Commission, and other State agencies have identified seven management measures to address nonpoint sources of pollution from hydromodification. Hydromodification is the alteration of stream and river channels, installation of dams and water impoundments, and streambank and shoreline erosion. The management measures consist of a suite of plans, practices, technologies, operating methods, or other alternatives that may be used in combination to control nonpoint source (NPS) pollution. Associated with each management measure are management practices that are designed to reduce the quantities of pollutants entering receiving waters. The fact sheet prepared for each management measure informs readers of the programs, resources, and case studies specific to California and the management measure.

The seven hydromodification management measures are separated into four categories: (1) channelization and channel modification; (2) dams, (3) streambank and shoreline erosion, and (4) education and outreach. Channelization and channel modification activities straighten, enlarge, deepen, or relocate the natural channel of rivers and streams. Channelization and channel modification activities diminish the quality of aquatic habitats and streamside habitats. It can alter the instream pattern of water temperature and sediment type, as well as the rate of sediment erosion, transport, and deposition. Hardening the banks of streams and rivers with shoreline stabilization protection or armor can accelerate the movement of surface water and pollutants from upstream, causing decreased water quality.

Dams can adversely impact the hydrology and quality of surface waters and riparian habitat in the rivers and streams where they are located. For the purposes of these management measures, dams are defined as constructed impoundments that are either (1) 25 feet or more in height and greater than 15 acre-feet in capacity, or (2) 6 feet or more in height and greater than 50 acre-feet in capacity. Impacts on surface waters and riparian habitats can result from the siting, construction, and operation of dams. Dams can reduce downstream flows affecting water quality and habitat. Construction of the dam can remove vegetation, cause increased sedimentation and turbidity. Shoreline and streambank erosion can occur after installation of a dam, which results in increased sediment load in the water body, affecting aquatic habitats.

The erosion of streambanks and shorelines is a natural process that can be beneficial and detrimental. Some erosion is necessary to provide sediment for beaches in estuaries and coastal bays, to provide point bars and channel deposits in rivers, and for substrate in tidal flats in wetlands. Excessively high erosion can cause sediment to smother aquatic vegetation, cover shellfish beds and tidal flats, fill in riffle pools, and contribute to increased turbidity and nutrients.

Plan for California’s Nonpoint Source Pollution Control Program Volume II: California Management Measures for Polluted Runoff (SWRCB and CCC, 2000) defines the even hydromodification management measures as follows:

Plan for California’s Nonpoint Source Pollution Control Program Volume II: California Management Measures for Polluted Runoff (SWRCB and CCC, 2000) defines the even hydromodification management measures as follows:
• **Channelization and Channel Modification.** California’s management measures for channelization and channel modification promote the evaluation of channelization and channel modification projects. Channels should be evaluated as a part of the watershed planning and design processes, including watershed changes from new development in urban areas, agricultural drainage, or forest clearing. The purpose of the evaluation is to determine whether resulting NPS changes to surface water quality (Management Measure 5.1A. Physical and Chemical Characteristics of Surface Waters) or instream and riparian habitat (Management Measure 5.1B. Instream and Riparian Habitat Restoration) can be expected and whether these changes will be good or bad. Existing channelization and channel modification projects can be evaluated to determine the NPS impacts and benefits associated with the projects. Modifications to existing projects, including operation and management, can also be evaluated to determine the possibility of improving some or all of the effects without changing the existing benefits or creating additional problems. In both new and existing channelization and channel modification projects, evaluation of benefits and/or problems should be site-specific.

• **Dams.** The second category of management measures addresses NPS pollution associated with dams. Dams are defined as constructed impoundments that are either (1) 25 feet or more in height and greater than 15 acre-feet in capacity, or (2) 6 feet or more in height and greater than 50 acre-feet in capacity. Management Measure 5.2A. Erosion and Sediment Control and Management Measure 5.2B. Chemical and Pollutant Control address two problems associated with dam construction: (1) increases in sediment delivery downstream resulting from construction and operation activities, and (2) spillage of chemicals and other pollutants to the waterway during construction and operation. Management Measure 5.2C. Protection of Surface Water Quality and Instream and Riparian Habitat addresses the impacts of reservoir releases on the quality of surface waters and instream and riparian habitat downstream.

• **Streambank and Shoreline Erosion.** Management Measure 5.3A. Eroding Streambanks and Shorelines addresses the stabilization of eroding streambanks and shorelines in areas where streambank and shoreline erosion creates a polluted runoff problem. Bioengineering methods such as marsh creation and vegetative bank stabilization are preferred. Streambank and shoreline features that have the potential to reduce polluted runoff should be protected from impacts, including erosion and sedimentation resulting from uses of uplands or adjacent surface waters. This management measure does not imply that all shoreline and streambank erosion must be controlled; the measure applies to eroding shorelines and streambanks that constitute a NPS problem in surface waters.

• **Education/Outreach.** Management Measure 5.4A. Educational Programs focuses on the development and implementation of pollution prevention and education programs for agency staffs and the public, as well as the promotion of assistance tools that emphasize restoration and low impact development. Education, technical assistance, incentives, and other means can be used to promote projects that reduce NPS pollutants, which retain or reestablish natural hydrologic functions (e.g., channel restoration projects and low impact development projects), and which prevent and remedy adverse effects of hydromodification activities.

### 2.5.1.2 General Resources

There are several federal and State agencies and programs that can provide general information to address NPS pollution from hydromodification from entering receiving waters. The agencies and programs listed below can provide assistance and information for all seven management measures. Resources specific to each of the seven hydromodification management measures can be found on the corresponding fact sheet.
Hydromodification

- **California Coastal Commission** ([http://www.coastal.ca.gov/](http://www.coastal.ca.gov/)): The California Coastal Commission's primary mission is to plan for and regulate land and water uses in the coastal zone consistent with the policies of the Coastal Act. Programs include permitting, planning, enforcement, and resource protection.

- **The Coastal NPS Pollution Control Program** ([http://www.coastal.ca.gov/nps/npsndx.html](http://www.coastal.ca.gov/nps/npsndx.html)): This program addresses nonpoint pollution problems in coastal waters. In its program, a state or territory describes how it will implement NPS pollution controls. This program is administered jointly with the U.S. Environmental Protection Agency (USEPA) and the National Oceanic and Atmospheric Administration (NOAA).

- **U.S. Army Corps of Engineers (USACE)** ([http://www.spd.usace.army.mil/](http://www.spd.usace.army.mil/)): USACE’s mission is to provide quality, responsive engineering services to the nation including: planning, designing, building, and operating water resources and other civil works projects; designing and managing the construction of military facilities for the Army and Air Force; and providing design and construction management support for other defense and federal agencies.

- **U.S. Fish and Wildlife Service South Pacific Division** ([http://www.fws.gov/](http://www.fws.gov/)): The South Pacific Division’s mission is to conserve, protect, and enhance the nation's fish and wildlife and their habitats for the continuing benefit of people.

2.5.1.3 References

### 2.5.2 Management Measure 5.1A

**Channelization and Channel Modification**

**Physical and Chemical Characteristics of Surface Waters**

**Management Measure**

1. Evaluate the potential effects of proposed channelization and channel modification on the physical and chemical characteristics of surface waters.

2. Plan and design channelization and channel modification to reduce undesirable impacts.

3. Develop an operation and maintenance program for existing modified channels that includes identification and implementation of opportunities to improve the physical and chemical characteristics of surface waters in those channels.

#### 2.5.2.1 Programs

- California Environmental Resources Evaluation System (CERES) is an information system developed by the California Resources Agency to facilitate access to a variety of electronic data describing California's rich and diverse environments. The goal of CERES is to improve environmental analysis and planning by integrating natural and cultural resource information from multiple contributors and by making it available and useful to a wide variety of users ([http://ceres.ca.gov/](http://ceres.ca.gov/)).

- The CALFED Bay-Delta Program aims to improve the quality and reliability of California's water supplies and revive the San Francisco Bay-Delta ecosystem. Its Web site contains information about water supply, water quality, and ecosystem restoration ([http://www.calwater.ca.gov/](http://www.calwater.ca.gov/)).

- The California Department of Fish and Game (DFG) has jurisdictional authority over wetland resources associated with rivers, streams, and lakes under California Fish and Game Code sections 1600 to 1607 (City of Palo Alto, 2001). The DFG has the authority to regulate work that will substantially divert, obstruct, or change the natural flow of a river, stream, or lake; substantially change the bed, channel, or bank of a river, stream, or lake; or use material from a streambed. Typical activities regulated by DFG under sections 1600–1607 authority include rechanneling and diverting streams, stabilizing banks, implementing flood control projects, river and stream crossings, diverting water, damming streams, gravel mining, and logging operations. The DFG encourages completion of a Streambed Alteration Agreement, which is a mutual agreement between the DFG and the project proponent ([http://www.dfg.ca.gov/1600/](http://www.dfg.ca.gov/1600/)).

#### 2.5.2.2 Management Practices

This management measure applies to any proposed channelization or channel modification project to evaluate potential changes in surface water characteristics, as well as to existing modified channels that can be targeted for opportunities to improve the surface water characteristics necessary to support desired fish and wildlife.
Changes created by channelization and channel modification activities are problematic if they unexpectedly alter environmental parameters to levels outside normal or desired ranges. The physical and chemical characteristics of surface waters that may be influenced by channelization and channel modification include sedimentation, turbidity, salinity, temperature, nutrients, dissolved oxygen, oxygen demand, and contaminants. Changes in natural sediment supplies, reduced freshwater availability, and accelerated delivery of pollutants are examples of the types of changes that can be associated with channelization and channel modification.

In cases where existing channelization or channel modification projects can be changed to enhance instream or streamside characteristics, several practices can be included as a part of regular operation and maintenance programs. New channelization and channel modification projects that cause unavoidable physical or chemical changes in surface waters can also use one or more practices to mitigate the undesirable changes. The practices include the following:

- **Structural practices** to protect or rehabilitate eroded streambanks are usually implemented in combination to provide stability of the stream system, and they can be grouped into direct and indirect methods. Direct methods include stone riprap revetments, erosion control fabrics and mats, revegetation, burlap sacks, cellular concrete blocks, and bulkheads. Indirect methods include the following: dikes, wire or board fences, gabions, and stone longitudinal dikes.

- **Levees** are embankments or shaped mounds constructed for flood control or hurricane protection.

- **Setback levees and floodwalls** are longitudinal structures used to reduce flooding and minimize sedimentation problems associated with fluvial systems. They can be constructed without disturbing the natural channel vegetation, cross section, or bottom slope.

- **Check dams** are small dams constructed across an influent, intermittent stream, or drainageway to reduce channel erosion by restricting flow velocity. They can serve as emergency or temporary measures in small eroding channels that will be filled or permanently stabilized at a later date, such as in a construction setting.

- **Grade control structures** are hydraulic barriers (weirs) installed across streams to stabilize the channel, control headcuts and scour holes, and prevent upstream degradation. These structures can be built with a variety of materials, including sheet piling, stone, gabions, or concrete.

- **Vegetative cover** is used to protect or rehabilitate eroded streambanks. Streambank protection using vegetation is probably the most commonly used practice, particularly in small tributaries. Vegetative cover, also used in combination with other structural practices, is relatively easy to establish and maintain, is visually attractive, and is the only streambank stabilization method that can repair itself when damaged. Appropriate native plant species should be used.

- **Structural, vegetative, or bioengineered practices** are used to control instream sediment load. Streambank protection and channel stabilization practices, including various types of revetments, grade control structures, and flow restrictors, have been effective in controlling sediment production caused by streambank erosion.

- **To minimize erosion and prevent sedimentation impacts on nearby water bodies during construction and operation periods, streamside roadway management needs to combine proper design for site-specific conditions with appropriate maintenance practices.**
Changes created by channelization and channel modification activities are problematic if they unexpectedly alter environmental parameters to levels outside normal or desired ranges. The physical and chemical characteristics of surface waters that may be influenced by channelization and channel modification include sedimentation, turbidity, salinity, temperature, nutrients, dissolved oxygen, oxygen demand, and contaminants. Changes in natural sediment supplies, reduced freshwater availability, and accelerated delivery of pollutants are examples of the types of changes that can be associated with channelization and channel modification.

In cases where existing channelization or channel modification projects can be changed to enhance instream or streamside characteristics, several practices can be included as a part of regular operation and maintenance programs. New channelization and channel modification projects that cause unavoidable physical or chemical changes in surface waters can also use one or more practices to mitigate the undesirable changes. The practices include the following:

- Structural practices to protect or rehabilitate eroded streambanks are usually implemented in combination to provide stability of the stream system, and they can be grouped into direct and indirect methods. Direct methods include stone riprap revetments, erosion control fabrics and mats, revegetation, burlap sacks, cellular concrete blocks, and bulkheads. Indirect methods include the following: dikes, wire or board fences, gabions, and stone longitudinal dikes.

- Levees are embankments or shaped mounds constructed for flood control or hurricane protection.

- Setback levees and floodwalls are longitudinal structures used to reduce flooding and minimize sedimentation problems associated with fluvial systems. They can be constructed without disturbing the natural channel vegetation, cross section, or bottom slope.

- Check dams are small dams constructed across an influent, intermittent stream, or drainageway to reduce channel erosion by restricting flow velocity. They can serve as emergency or temporary measures in small eroding channels that will be filled or permanently stabilized at a later date, such as in a construction setting.

- Grade control structures are hydraulic barriers (weirs) installed across streams to stabilize the channel, control headcuts and scour holes, and prevent upstream degradation. These structures can be built with a variety of materials, including sheet piling, stone, gabions, or concrete.

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- Structural, vegetative, or bioengineered practices are used to control instream sediment load. Streambank protection and channel stabilization practices, including various types of revetments, grade control structures, and flow restrictors, have been effective in controlling sediment production caused by streambank erosion.

- To minimize erosion and prevent sedimentation impacts on nearby water bodies during construction and operation periods, streamside roadway management needs to combine proper design for site-specific conditions with appropriate maintenance practices.
2.5.2.3 Information Resources

- **North Delta Improvements Project** ([http://ndelta.water.ca.gov/index.html](http://ndelta.water.ca.gov/index.html)): The (NDIP), which is under the Department of Water Resources, presents unique opportunities for synergy in achieving flood control and ecosystem restoration goals.

- **South Delta Improvement Project** ([http://sdelta.water.ca.gov/](http://sdelta.water.ca.gov/)): The purpose of the South Delta Improvements Program (SDIP) is to incrementally maximize diversion capability into Clifton Court Forebay, while providing an adequate water supply for diverters within the South Delta Water Agency, and reducing the effects of State Water Project exports on both aquatic resources and direct losses of fish in the South Delta.

- **Washington State Department of Transportation** ([http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBwebsite/mainpage/](http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBwebsite/mainpage/): This is a comprehensive Web site, with information on cost, specifications, funding, and case studies.

- **California Forest Stewardship Program. Bioengineering to Control Streambank Erosion** ([http://ceres.ca.gov/foreststeward/html/bioengineering.html](http://ceres.ca.gov/foreststeward/html/bioengineering.html)): This fact sheet discusses various bioengineering techniques applicable to California streams.

- **WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System** ([http://www.water.ncsu.edu/watershedss/info/bmps.html](http://www.water.ncsu.edu/watershedss/info/bmps.html)): These fact sheets provide information on a variety of techniques for management practices, including soil bioengineering, structural streambank stabilization, and instream practices.

- **Ohio Department of Natural Resources. Stream Management Guide Fact Sheets** ([http://www.dnr.state.oh.us/water/pubs/fs_st/streamfs.htm](http://www.dnr.state.oh.us/water/pubs/fs_st/streamfs.htm)): This is a compilation of fact sheets on technical guidance for streambank and instream practices, general stream management, and stream processes.

2.5.2.4 Case study

**Urban Stream Restoration Program.** In 2000, a 900-linear-foot reach of degraded stream flowing through a well-used city park was restored by regrading the channel and increasing its sinuosity. The banks were revegetated using native willow and cottonwood cuttings and close to 100 native trees and shrubs from container stock. The East Bay Conservation Corps, under the supervision of the Urban Creeks Council, provided the labor. The California Department of Water Resources, Urban Stream Restoration Program, California Coastal Conservancy, and the San Francisco Foundation funded this project ([http://www.urbancreeks.org/Current_Projects.htm](http://www.urbancreeks.org/Current_Projects.htm)).

**Hunter Creek Salmon and Steelhead Habitat Restoration Project.** This project, implemented in 1998 by the California Conservation Corps with guidance from California Department of Fish and Game and U.S. Fish and Wildlife Service, was designed to improve the physical and chemical characteristics of the creek to provide a more suitable habitat. The specific goals of the project were to improve water quality, instream habitat, and the riparian area along the creek. The project had five components:

- **Cleanup**: Approximately 40 car bodies were removed from the streambank.

- **Instream structures**: Boulders, wood structures, and willow posts were placed in the stream and on the streambank to provide habitat complexity and to stabilize streambanks.

- **Fencing to exclude cattle**: The area along both sides of Hunter Creek was fenced to exclude cattle.
Hydromodification

- **Planting native vegetation**: Native trees were planted alongside the stream, including willow, alder, Sitka spruce, western red cedar, Douglas fir, coast redwood, big-leaf maple, and black cottonwood.

- **Monitoring**: Photographs are taken at specific locations twice per year to monitor project effectiveness and habitat changes.

More information about this project can be obtained by contacting Scott Bauer of the California Conservation Corps, Klamath Service District, Phone: 707-482-2941; E-mail: sbauer@ccc.ca.gov.

2.5.2.5 References


2.5.3 Management Measure 5.1B
Channelization and Channel Modification
Instream and Riparian Habitat Restoration

Management Measure

1. Evaluate the potential effects of proposed channelization and channel modification on instream and riparian habitat.

2. Plan and design channelization and channel modification to reduce undesirable impacts.

3. Develop an operation and maintenance program for existing modified channels that includes identification and implementation of opportunities to restore instream and riparian habitat in those channels.

2.5.3.1 Programs

- CALFED Bay-Delta Program mission is to develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta System (http://calwater.ca.gov/).

- The California Ecological Restoration Projects Inventory (CERPI) is a comprehensive electronic database with details on restoration projects in California. It is searchable on the Internet as part of the Natural Resource Project Inventory (NRPI). The project is the result of collaboration between the California Biodiversity Council and the University of California, Davis, Information Center on the Environment (http://www.ice.ucdavis.edu/nrpi/).

- The Riparian Habitat Joint Venture, started by the California Partners in Flight (CalPIF), is a collaborative effort between 18 federal, state, and private organizations. The focus of the venture is to protect and improve riparian zones bordering streams and lakes (http://www.prbo.org/calpif/htmldocs/rhjv/).

- The Salmon Restoration Project is the result of cooperation between the California Conservation Corps, and California Department of Fish and Game. The agencies have been working in partnership with private and public landowners to restore California's salmon and steelhead habitat by adding instream structures. These structures provide shelter for fish, help reduce water temperatures, and add ecological complexity to the stream channel (http://www.ccc.ca.gov/cccweb/DISTRICT/SHASTAPA/SRP/srp.htm).
2.5.3.2 Management Practices

The purpose of this management measure is to correct and prevent further detrimental changes to instream and riparian habitat caused by channelization and channel modification projects. The management measure generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. Implementation practices for instream and riparian habitat restoration in planned or existing modified channels are consistent with those management practices for physical and chemical characteristics of channelized or modified surface waters. To prevent future impacts on instream or riparian habitat or to remedy current problems caused by channelization or channel modification projects, include one or more of the following practices to mitigate the undesirable changes.

- Structural practices to rehabilitate eroded streambanks are usually implemented in combination to provide stability of the stream system, and they can be grouped into direct and indirect methods. Direct methods include stone riprap revetments, erosion control fabrics and mats, revegetation, burlap sacks, cellular concrete blocks, and bulkheads. Indirect methods include the following: dikes, wire or board fences, gabions, and stone longitudinal dikes.

- Levees are embankments or shaped mounds constructed for flood control or hurricane protection.

- Setback levees and floodwalls are longitudinal structures used to reduce flooding and minimize sedimentation problems associated with fluvial systems. They can be constructed without disturbing the natural channel vegetation, cross section, or bottom slope.

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- Structural, vegetative, or bioengineered practices are used to control instream sediment load. Streambank and channel stabilization practices, including various types of revetments, grade control structures, and flow restrictors, have been effective in controlling sediment production caused by streambank erosion.

- To minimize erosion and remedy sedimentation impacts on nearby water bodies during construction and operation periods, streamside roadway management needs to combine proper design for site-specific conditions with appropriate maintenance practices.

2.5.3.3 Information Resources

- Lower American River Corridor River Management Plan (http://www.safca.com): The plan has a section on aquatic habitat management goals, which includes restoration to improve aquatic habitat impaired by low flows from channel modification of the Lower American River.
Welcome and User’s Guide to the San Pablo Bay Watershed Restoration Program: The San Pablo Bay Watershed Restoration Program is an innovative new effort to restore the ecological vitality of the San Pablo Bay watershed. There are many unique opportunities to revitalize streams, rivers, and wetlands in this large, northern San Francisco Bay region, and the Watershed Restoration Program creates a framework to promote its rejuvenation.

South Sacramento County Streams Project: The South Sacramento County Streams Project provides flood damage reduction to the urban areas of the Morrison Creek and Beach Stone Lake drainage basins in the southern area of Sacramento, as well as around the Sacramento Regional Waste Water Treatment Plant. The project will fund stream restoration in southern Sacramento County.

Sacramento River Riparian Habitat Program: The Sacramento River Riparian Habitat Program is working to ensure that riparian habitat management along the river addresses the dynamics of the riparian ecosystem and the reality of the local agricultural economy.

Washington State Department of Transportation, Soil Bioengineering Web site: This is a comprehensive Web site, with information on cost, specifications, funding, and case studies.

California Forest Stewardship Program, Bioengineering to Control Streambank Erosion: This fact sheet discusses various bioengineering techniques applicable to California streams.

WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System: These fact sheets provide information on a variety of techniques for management practices, including soil bioengineering, structural streambank stabilization, and instream practices.

Ohio Department of Natural Resources, Stream Management Guide Fact Sheets: This is a compilation of fact sheets on technical guidance for streambank and instream practices, general stream management, and stream processes.

USDA Natural Resources Conservation Service, Stream Visual Assessment Protocol: This document outlines methods useful for field conservationists and landowners for the evaluation of the ecological condition of a stream.

Ann Riley, Urban Stream Restoration: A Video Tour of Ecological Restoration Techniques: This video, which is 61 minutes long and can be ordered online, is a documentary tour of six urban stream restoration sites. It provides background information on funding, community involvement, and the history and principles of restoration. The demonstration includes examples of stream restoration in very urbanized areas, re-creating stream shapes and meanders, creek daylighting, soil bioengineering, and ecological flood control projects. Ann Riley, a nationally known hydrologist, stream restoration professional, and executive director of the Waterways Restoration Institute in Berkley, California, leads the tour.

Natural Resources Conservation Service, Watershed Technology Electronic Catalog: This online catalog is a source of technical guidance on a variety of restoration techniques and management practices, to provide direction for watershed managers and restoration practitioners. The site is focused on providing images and conceptual diagrams.
2.5.3.4 Case Study

*Urban Stream Restoration Program.* In 2000, a 350-linear-foot section of degraded stream was restored, and failing concrete banks were stabilized using soil-bioengineering techniques (brush layering). Native riparian trees, willows, and cottonwood cuttings were planted, and a trail was graded along one bank. The East Bay Conservation Corps, under the supervision of the Urban Creeks Council, provided the labor. The California Department of Water Resources, Urban Stream Restoration Program, California Coastal Conservancy, and the San Francisco Foundation funded this project (http://www.urbancreeks.org/Current_Projects.htm).

*Mill Creek Channel Restoration Project.* In 2001, Round Valley Indian Tribes, partnering with the FishAmerica Foundation and the National Oceanic and Atmospheric Administration’s Restoration Center, initiated a project to restore this stream, located in Mendocino County, California. The purpose of the restoration was to reestablish and improve salmonid habitat within Mill Creek by creating a single, deeper stream channel and a functional riparian corridor. Restoration techniques included the use of riprap wing deflectors, structural streambank stabilization, boulder weirs, and large woody debris. The local community is participating through an Adopt-A-Watershed program, which provides an opportunity for local schools to monitor the success of the project and track changes in the health of the stream (http://yosemite.epa.gov/water/restorat.nsf/California?OpenView).

2.5.3.5 References

2.5.4 Management Measure 5.2A

Dams

Erosion and Sediment Control

Management Measure

1. Reduce erosion and, to the extent practicable, retain sediment onsite during and after construction.

2. Prior to land disturbance, prepare and implement an approved erosion and sediment control plan or similar administrative document that contains erosion and sediment control provisions.

2.5.4.1 Programs

- The California Water Code entrusts the regulatory Dam Safety Program to the Department of Water Resources. The principal goal of this program is to avoid dam failure and thus prevent loss of life and destruction of property. Dams under State jurisdiction are an essential element of the California infrastructure that provides constant water supply integrity (http://damsafety.water.ca.gov).

- The Bureau of Reclamation’s Dam Safety Program must ensure that dams are operated and maintained in a safe manner through inspections for safety deficiencies, analyses using current technologies and designs, and corrective actions, if needed, based on current engineering practices. In addition, future evaluations should include assessments of benefits forgone with the loss of a dam. For example, a failed dam can no longer provide needed fish and wildlife benefits (http://www.usbr.gov/ssle/dam_safety/).

- Both Edison Mission Energy and Southern California Edison use hydropower to generate electricity. Using moving water to effectively generate electricity is clean and environmentally safe; however, it affects portions of streams from which water is diverted, and it can create reservoirs that have both positive and negative impacts. Edison International works with local groups and government agencies to increase the benefits of hydroelectric operations and reduce negative impacts. (Southern California Edison's Big Creek hydro facilities re-licensing has an environmental program. Information is not yet available on its Web site: http://www.sce.com/sc3/006_about_sce/006b_generation/006b2_big_creek/default.htm.

2.5.4.2 Management Practices

Two broad performance goals constitute this management measure: minimizing erosion and maximizing the retention of sediment onsite. Preparing and implementing an erosion and sediment control plan for dam construction and operation can accomplish these goals. The goals give states and local governments flexibility in specifying practices appropriate for local conditions. Recommended practices to control erosion and sediment control from dams include the following:

- Develop and implement an erosion and sediment control plan (ESC plan) for the dam. These plans describe how a contractor or developer will reduce soil erosion and contain and treat runoff that is carrying eroded sediments. Plans typically include descriptions and locations of soil stabilization practices, perimeter controls, and runoff treatment facilities that will be installed and maintained before and during construction activities. In addition to special area considerations, the full ESC plan review inventory should include topographic and vicinity maps, a site...
development plan, construction schedule, erosion and sedimentation control plan drawings, detailed drawings and specifications for practices, design calculations, and a vegetation plan. Changes to an ESC plan should be made based on regular inspections that determine whether the ESC practices were appropriate or properly installed or maintained.

- Provide education and training opportunities for designers, developers, and contractors. One of the most important factors determining whether erosion and sediment controls will properly be installed and maintained on a construction site is the knowledge and experience of the contractor.

- Schedule projects so clearing and grading are done during the time of minimum erosion potential. Often a project can be scheduled during the time of year when the erosion potential of the site is relatively low. In many parts of the country, there is a certain period of the year when erosion potential is relatively low and construction scheduling could be very effective (in the Pacific region, for example, the 6-month dry season from May 1 to October 31).

- Plan to use construction phasing. Construction site phasing involves disturbing only small portions of a site at a time to prevent erosion from dormant parts. Elements to consider when phasing construction activities include managing runoff separately in each phase, determining whether water and sewer connections and extensions can be accommodated, determining the fate of already completed downhill phases, and providing separate construction and residential accesses to prevent conflicts between residents living in completed stages of the site and construction equipment working on later stages.

2.5.4.3 Information Resources

- **California Storm Water Quality Association, Construction Handbook** ([http://www.cabmphandbooks.org/Construction.asp](http://www.cabmphandbooks.org/Construction.asp)): The Construction Handbook provides general guidance for selecting and implementing management practices that will eliminate or reduce the discharge of pollutants from construction sites to waters of the State. The practices for erosion and sediment control are included in Section 3 of the handbook.

- **California Coastal Commission, Beach Erosion and Response Document**

  The Beach Erosion and Response Guidance Document, or BEAR, is now available by request from the California Coastal Commission. This document provides general information about types of shorelines and seawalls, as well as guidance for analyzing shoreline activities. To receive a copy, call the Technical Services Unit in the Headquarters Office (Telephone: 415-904-5240).

- **Resources Agency of California, Draft Policy on Coastal Erosion Planning and Response and Background Material**

  The draft policy on coastal erosion planning and response focuses on responding to erosion at the coastline with actions that will cause the least environmental damage, while protecting existing coastal infrastructure. The draft policy outlines a tiered approach that proposes the following broad policy goals: (1) increasing sand supply to the coast; (2) avoiding the construction of new structures in hazardous areas; (3) if structures are threatened, considering the feasibility of relocating them; (4) using beach nourishment (placing sand on or near eroding beaches) as the first priority for stabilizing beaches, if feasible; (5) using hard protective structures (seawalls, revetments, breakwaters, etc) only if other less environmentally damaging alternatives are deemed infeasible. The draft policy and background material can be found at [http://resources.ca.gov/ocean/coastal_erosion_draft.html](http://resources.ca.gov/ocean/coastal_erosion_draft.html).

- **Russellville Water Intake Environmental Assessment** ([http://www.tva.gov/environment/reports/russell/ea_text.htm](http://www.tva.gov/environment/reports/russell/ea_text.htm)): This environmental assessment was prepared for the addition of a special reservoir drawdown during construction of intake at mile 32.4R on Cedar Creek Reservoir, Franklin County, Alabama.
California Nonpoint Source Encyclopedia  Hydromodification

- **Wyoming Department of Environmental Quality, Hydrologic Modifications Best Management Practices** ([http://deq.state.wy.us/wqd/watershed/Downloads/NPS Program/92251.pdf](http://deq.state.wy.us/wqd/watershed/Downloads/NPS Program/92251.pdf)): This manual provides information on the management practices recommended by the Wyoming Department of Environmental Quality for protecting streams and riparian areas from hydrologic modifications.
2.5.5 Management Measure 5.2B
Dams
Chemical and Pollutant Control

Management Measure

1. Limit application, generation, and migration of toxic substances.
2. Ensure the proper storage and disposal of toxic materials.
3. Apply nutrients at rates necessary to establish and maintain vegetation without causing significant nutrient runoff to surface waters.

2.5.5.1 Programs

- The Bureau of Reclamation’s Dam Safety Program must ensure that dams are operated and maintained in a safe manner through inspections for safety deficiencies, analyses using current technologies and designs, and corrective actions, if needed, based on current engineering practices. In addition, future evaluations should include assessments of benefits forgone with the loss of a dam. For example, a failed dam can no longer provide needed fish and wildlife benefits (http://www.usbr.gov/ssle/dam_safety/).
- The California Resources Agency, Department of Water Resources, Division of Safety of Dams conducts investigations of selected dams, which include a comprehensive review of all pertinent material contained in the Division’s files, a visual project inspection, technical studies when necessary, and preparation of a comprehensive report (http://damsafety.water.ca.gov/about.htm).

2.5.5.2 Management Practices

The purpose of this management measure is to prevent downstream contamination from pollutants associated with dam construction and maintenance activities. Recommended practices used to control chemical pollution from dam construction sites include the following:

- Develop and implement a spill prevention program. Spill procedure information should be posted, and persons trained in spill handling should be onsite or on call at all times. Materials for cleaning up spills should be kept onsite and easily available. Spills should be cleaned up immediately and the contaminated material properly disposed of.
- Control pollutant runoff from equipment. During both construction and maintenance activities at dams, equipment and machinery can be a potential source of pollution to the surface and ground waters.
- Establish fuel and maintenance staging areas. Proper maintenance of equipment and installation of proper stream crossings further reduces pollution of water by these sources. Vehicles need to be inspected for leaks. To prevent runoff, fuel and maintain vehicles onsite only in a bermed area or over a drip pan.
- Store, cover, and isolate construction materials, refuse, garbage, sewage, debris, oil and other petroleum products, mineral salts, industrial chemicals, and topsoil to prevent runoff of pollutants and contamination of ground water.

Last Updated July 30, 2004
• Mix, transport, load, and apply pesticides correctly and dispose of their containers properly to prevent potential NPS pollution. Fertilizers should be handled and applied properly.

2.5.5.3 Information Resources

• USEPA, Spill Prevention Planning (http://www.epa.gov/npdes/pubs/spillprv.pdf): This fact sheet outlines key programmatic components to establishing spill prevention plans.
### 2.5.6 Management Measure 5.2C

**Dams**

**Protection of Surface Water Quality and Instream and Riparian Habitat**

<table>
<thead>
<tr>
<th>Management Measure</th>
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<tr>
<td>Develop and implement a program to manage the operation and maintenance of dams that includes an assessment of</td>
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<tr>
<td>1. Surface water quality and instream and riparian habitat and potential for improvement, and</td>
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<tr>
<td>2. Significant NPS pollution problems that result from excessive surface water withdrawals.</td>
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#### 2.5.6.1 Programs

- The Department of Fish and Game is responsible for conserving, protecting, and managing California's fish, wildlife, and native plant resources. To meet this responsibility, the law requires any person, State, or local government agency, or public utility proposing a project that may impact a river, stream, or lake to notify the Department before beginning the project. If the Department determines that the project may adversely affect existing fish and wildlife resources, a Lake or Streambed Alteration Agreement is required ([http://www.dfg.ca.gov/1600/](http://www.dfg.ca.gov/1600/)).

- California Department of Water Resources Fish Passage Improvement Program staff meet with local, State, and federal agencies and stakeholder partners to plan and implement projects to remove barriers that impede migration and spawning of anadromous fish species. This program’s Web site has a link to a table of dams removed in California ([http://www.isi.water.ca.gov/fish/dams.shtml](http://www.isi.water.ca.gov/fish/dams.shtml)).

- The goal of the American Rivers campaign, Rivers Unplugged, is to restore rivers critical to fish and wildlife by removing dams that no longer make sense. The primary focus of the Rivers Unplugged California Field Office is to provide technical assistance and other guidance to individual dam removal efforts ([http://www.amrivers.org/contactus/california2.htm](http://www.amrivers.org/contactus/california2.htm)).

#### 2.5.6.2 Management Practices

The purpose of this management measure is to protect the quality of surface waters and aquatic habitat in reservoirs and in the downstream portions of rivers and streams that are influenced by the quality of water contained in the releases (tailwaters) from reservoir impoundments. Impacts from the operation of dams on surface water quality and aquatic and riparian habitat should be assessed and the potential for improvement evaluated. In addition, potential upstream and downstream impacts on surface water quality and aquatic and riparian habitat that would be caused by the implementation of practices should also be considered in the assessment. The overall program approach is to evaluate a set of practices that can be applied individually or in combination to protect and improve surface water quality and aquatic habitat in reservoirs, as well as in areas downstream of dams. After this evaluation, the most cost-effective operations should be implemented to protect and improve, where economically feasible, surface water quality and aquatic and riparian habitat.

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_Last Updated July 30, 2004_
Recommended practices for aeration of reservoir waters and releases include the following:

- **Pumping and injection systems.** Water pumps have been used to move surface water containing higher concentrations of dissolved oxygen downward to mix with deeper waters as the two strata are entering the turbine. Oxygen injection systems use pure oxygen to increase levels of dissolved oxygen in reservoirs.
- **Turbine venting.** This is the practice of injecting air into water as it passes through a turbine.

Recommended practices to improve oxygen levels in tailwaters include the following:

- **Gated conduits.** These are hydraulic structures that divert the flow of water under the dam. They are designed to create turbulent mixing to enhance the rest of the oxygen transfer.
- **Spillways and overflow weirs.** These are important structures in improving dissolved oxygen levels.
- **Spillway modifications.** Spillways can be modified by cutting a notch to prevent water from plunging directly into the stilling basin.
- **Reregulation weirs.** This type of weir has been constructed from stone, wood, and aggregate. In addition to increasing the levels of dissolved oxygen in the tailwaters, reregulation weirs result in a more constant rate of flow farther downstream during periods when turbines are not in operation.
- **Labyrinth weirs.** This type of weir has extended crest length and is usually W-shaped. These weirs spread the flow out to prevent dangerous undertows in the plunge pool.
- **Selective withdrawal.** Multilevel intake devices in storage reservoirs allow selective withdrawal of water based on temperature and dissolved oxygen levels.
- **Turbine operation.** Implementation of changes in the turbine start-up procedures can also enlarge the zone of withdrawal to include more of the epilimnetic waters in the downstream releases.

Recommended watershed protection practices include the following:

- **Land use planning.** Planning establishes guidelines for permissible uses of land within a watershed and serves as a guide for reservoir management programs addressing NPS pollution.
- **NPS screening and identification.** The analysis and interpretation of stereoscopic color infrared aerial photographs can be used to find and map specific areas of concern where a high probability of NPS pollution exists from septic tank systems, animal wastes, soil erosion, and other similar types of NPS pollution.
- **Soil erosion control.** Soil erosion has been determined to be the major source of suspended solids, nutrients, organic wastes, pesticides, and sediment that, when combined, form the most problematic form of NPS pollution.
- **Ground water protection.** Proper protection and management of ground water resources primarily depends on the effective control of NPS pollution, particularly in ground water recharge areas.
- **Mine reclamtion.** Old mines need to be located and reclaimed to reduce the NPS pollutants emanating from them. Revegetation is a cost-effective method of reclaiming denuded strip-mined lands.
- **Animal waste control.** A major contributor to reservoir pollution in some watersheds is wastes from confined animal facilities.
Failing septic system control. Septic systems should be sited, designed, and installed so that impacts on water bodies will be reduced to the extent practicable.

Practices to restore or maintain aquatic and riparian habitat include the following:

- **Flow augmentation.** A flushing flow is a high-magnitude, short-duration release for the purpose of maintaining channel capacity and the quality of instream habitat by scouring the accumulation of fine-grained sediments from the streambed.

- **Riparian improvements.** These include reducing sediment loading in the watershed, improving riparian vegetation, eliminating barriers to fish migration, and providing greater instream and riparian habitat diversity

Practices to maintain fish passage include the following:

- **Behavioral barriers.** Such barriers use fish responses to external stimuli to keep fish away from the intakes or to attract them to a bypass.

- **Physical barriers.** These include barrier nets and stationary screens to prevent the entry of fish and other aquatic organisms into the intakes at a generating facility.

- **Collection systems.** These are used to capture fish by screening and/or netting, followed by transport by truck or barge to a downstream location.

- **Fish diversion systems.** These lead or force fish to bypasses that transport them to the natural water body below the dam.

- **Spill and water budgets.** Spill budgets provide alternative methods for fish passage that are less dangerous than passage through turbines. The water budget is the mechanism for increasing flows through dams during the out-migration of anadromous fish species.

- **Fish ladders.** These are one type of structure that can be provided to enable the safe upstream and downstream passage of mature fish.

- **Transfer of fish runs.** Transfer involves inducing anadromous fish species to use different spawning grounds in the vicinity of the impoundment.

- **Constructed spawning beds.** When the adverse effects of a dam on the aquatic habitat of an anadromous fish species are severe, one option may be to construct suitable replacement spawning beds.

### 2.5.6.3 Information Resources

- **California Department of Water Resources Fish Passage Improvement Program, Bibliography** ([http://www.isi.water.ca.gov/fish/bibliography.shtml](http://www.isi.water.ca.gov/fish/bibliography.shtml)): This Web site provides several references on fish species biology, dam removal, geomorphology, fish passage structures, riparian and instream restoration, road crossings, and riparian vegetation.

- **California Department of Fish and Game (DFG), Lake or Streambed Alterations Agreements** ([http://www.dfg.ca.gov/1600/brochure.pdf](http://www.dfg.ca.gov/1600/brochure.pdf)): This brochure provides information on the DFG lake or streambed alterations notification and agreement program.

- **California Salmonid Stream Habitat Restoration Manual** ([http://www.dfg.ca.gov/nafwb/pubs/manual3.pdf](http://www.dfg.ca.gov/nafwb/pubs/manual3.pdf)): This manual formally explains and describes the DFG’s ground level approach to restoration of fishery resources, and standardizes the DFG’s descriptive terminology and technical methods. Principal emphasis is on salmon, steelhead, and
trout; therefore, this manual is principally intended to be used to assist in restoration efforts for those species in California.

2.5.6.4 Case Study

Battle Creek Restoration Project. A plan to restore rare Chinook salmon and steelhead by removing five dams, constructing fish ladders, and improving stream flow in 42 miles of Northern California's Battle Creek was announced in 1999. Spring-fed Battle Creek, a major Sacramento River tributary, is the first stream in California to which several species of salmon will be able to return and find their original spawning grounds.

The Battle Creek restoration proposal includes increasing the minimum instream flows from the present amount of 3 to 5 cubic feet per second (cfs) year round to approximately 35-88 cfs adjusted seasonally; decommissioning five diversion dams (Wildcat, Coleman, South, Lower Ripley Creek, and Soap Creek) and transferring their associated water rights to instream uses; screening and enlarging ladders at three diversion dams (Inskip, Eagle Canyon, and North Battle Creek Feeder); and constructing new infrastructure to eliminate mixing of North and South Fork waters. Screening prevents fish from getting pulverized in the dams' turbines.

This restoration is being done under the CALFED Bay-Delta Program, which was formed in 1994. It is a joint federal and State agreement to improve California's water and ecosystem quality as well as the water supply reliability and the vulnerability of Delta functions in and around San Francisco, Sacramento, and Stockton, CA (http://www.usbr.gov/mp/regional/battlecreek/f_overview.html).
2.5.7 Management Measure 5.3A
Streambank and Shoreline Erosion
Eroding Streambanks and Shorelines

Management Measure

1. Where streambank or shoreline erosion is a NPS problem, streambanks and shorelines should be stabilized. The use of vegetative stabilization methods is strongly preferred over the use of structural stabilization methods, if appropriate considering the climate, severity of wave and wind erosion, offshore bathymetry, and the potential adverse impacts on other streambanks, shorelines, and offshore areas.

2. Protect streambank and shoreline features with the potential to reduce NPS pollution.

3. Protect streambanks and shorelines from erosion due to uses of either the shorelands or adjacent surface waters.

2.5.7.1 Programs

- The California Coastal Commission's primary mission is to plan for and regulate land and water uses in the coastal zone consistent with the policies of the Coastal Act. Programs include permitting, planning, enforcement, and resource protection (http://www.coastal.ca.gov/).

- The CALFED Bay-Delta Program’s mission is to develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta System (http://www.calwater.ca.gov/).

- The California Department of Fish and Game’s mission is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public (http://www.dfg.ca.gov/).

2.5.7.2 Management Practices

- Use bioengineering and other vegetative techniques to restore damaged habitat along shorelines and streambanks wherever conditions allow.
  - Live staking involves the insertion and tamping of live, rootable vegetative cuttings into the ground.
  - Live fascines are long bundles of branch cuttings bound together into sausage-like structures. When cut from appropriate species and properly installed, they will root and immediately begin to stabilize slopes.
  - Brush layering consists of placing live branch cuttings in small benches excavated into the slope. The portions of the brush that protrude from the slope face assist in retarding runoff and reducing surface erosion.
  - Brush mattressing involves digging a slight depression on the bank and creating a mat or mattress from woven wire or single strands of wire and live, freshly cut branches from sprouting trees or shrubs.
- Branch packing consists of alternating layers of live branch cuttings and compacted backfill to repair small localized slumps and holes in slopes.
- Joint planting involves tamping live cuttings of rootable plant material into soil between the joints or open spaces in rocks that have previously been placed on a slope.
- Live cribwalls consist of a hollow, box-like interlocking arrangement of untreated log or timber members. The structure is filled with suitable backfill material and layers of live branch cuttings, which root inside the crib structure and extend into the slope.

- Use properly designed and constructed engineering practices for shore erosion control in areas where practices involving marsh creation and soil bioengineering are ineffective.
  - Bulkheads are primarily soil-retaining structures designed also to resist wave attack.
  - Seawalls are principally structures designed to resist wave attack, but they also may retain some soil. Both bulkheads and seawalls may be built of many materials, including steel, timber, or aluminum sheet pile, gabions, or rubble-mound structures.
  - Revetment design contains several layers of randomly shaped and randomly placed stones, protected with several layers of selected armor units or quarry stone. The armor units in the cover layer should be placed in an orderly manner to obtain good wedging and interlocking between individual stones. The cover layer may also be constructed of specially shaped concrete units.
  - Gabions (stone-filled wire baskets) or interlocking blocks of precast concrete are used in the construction of revetments. In addition to the surface layer of armor stone, gabions, or rigid blocks, successful revetment designs also include an underlying layer composed of either geotextile filter fabric and gravel or a crushed stone filter and bedding layer.
  - Groins are structures that are built perpendicular to the shore and extend into the water. Groins are generally constructed in series, referred to as a groin field, along the entire length of shore to be protected. Groins trap sand in littoral drift and halt its longshore movement along beaches. The sand beach trapped by each groin acts as a protective barrier that waves can attack and erode without damaging previously unprotected upland areas.
  - Breakwaters are wave energy barriers designed to protect the land or nearshore area behind them from the direct assault of waves.

- In areas where existing protection methods are being flanked or are failing, implement properly designed and constructed shore erosion control methods.
  - Toe protection usually takes the form of a stone apron installed at the base of the vertical structure to reduce wave reflection and scour of bottom sediments during storms.
  - Return walls should be provided at either end of a vertical protective structure and should extend landward for a horizontal distance consistent with the local erosion rate and the design life of the structure.
  - Maintenance of structures is necessary to repair the damage from storms and winter ice and to address the effects of flanking and offshore profile deepening.

- Plan and design all streambank, shoreline, and navigation structures so that they do not transfer erosion energy or otherwise cause visible loss of surrounding streambanks or shorelines. Many streambank or shoreline protection projects result in a transfer of energy from one area to another, which causes increased erosion in the adjacent area. Property owners should consider the possible effects of erosion control measures on other properties located along the shore.
No-wake zones should be established and enforced. No-wake zones should be given preference over posted speed limits in shallow coastal waters and inland lakes and streams for reducing the erosion potential of boat wakes on streambanks and shorelines.

Setbacks should be established to minimize disturbance of land adjacent to streambank and shorelines to reduce other impacts. Setbacks most often take the form of restrictions on the siting and construction of new standing structures along the shoreline.

Upland drainage from development should be directed away from bluffs and banks so as to avoid accelerating slope erosion.

2.5.7.3 Information Resources

- **Sacramento River Riparian Habitat Program** ([http://www.sacramentoriver.ca.gov/](http://www.sacramentoriver.ca.gov/)): The Sacramento River Riparian Habitat Program is working to ensure that riparian habitat management along the river addresses the dynamics of the riparian ecosystem and the reality of the local agricultural economy.

- **California Forest Stewardship Program, Bioengineering to Control Stream Bank Erosion** ([http://ceres.ca.gov/foreststeward/html/bioengineering.html](http://ceres.ca.gov/foreststeward/html/bioengineering.html)): This fact sheet includes information on using bioengineering techniques to control streambank erosion.

- **Bioengineering for Hillslope, Streambank, and Lakeshore Erosion Control** ([http://www.ianr.unl.edu/pubs/Soil/g1307.htm](http://www.ianr.unl.edu/pubs/Soil/g1307.htm)): This NebGuide (part of a series published by the Cooperative Extension of the University of Nebraska) describes bioengineering techniques for hill slope, streambank, and lakeshore erosion control. Tips for a successful bioengineering installation and demonstration project are described.

- **California Environmental Resources Evaluation System (CERES)** ([http://ceres.ca.gov/](http://ceres.ca.gov/)): CERES is an information system developed by the California Resources Agency to facilitate access to a variety of electronic data describing California's rich and diverse environments. The goal of CERES is to improve environmental analysis and planning by integrating natural and cultural resource information from multiple contributors and by making it available and useful to a wide variety of users.

2.5.7.4 Case Study

*Beaches Starved of Sand Because of Dams.* Four hundred miles of California’s fabulous beaches are starving for sand, but surfers and other beach lovers have the muscle to bring them back. Beaches are disappearing mostly because of dams. Seventy to 90 percent of the sand on California beaches comes from rivers, and millions of tons of sand-laden sediments are now trapped behind the 1,400 dams that were built in California between 1850 and 1970. Twenty percent of the sand on California’s beaches comes from the natural erosion of bluffs ([http://www.ecoiq.com/magazine/opinion/opinion61.html](http://www.ecoiq.com/magazine/opinion/opinion61.html)).

2.5.7.5 References

2.5.8 Management Measure 5.4A
Education/Outreach
Educational Programs

Implement educational programs to provide greater understanding of watersheds, to raise awareness and increase the use of applicable hydromodification management measures and practices where needed to control and prevent adverse impacts on surface and ground waters, and to promote projects that retain or reestablish natural hydrologic functions (e.g., channel restoration projects). Public education, outreach, and training programs should involve applicable user groups and the community.

2.5.8.1 Programs
- The Clean Water Team Citizen Monitoring Program is part of the SWRCB’s NPS Pollution Control Program. Regional coordinators provide technical assistance, training, data management consultation, outreach, and education to citizen monitoring organizations. The program provides an opportunity for the public to participate in stewardship efforts and learn about the issues facing their local watersheds (http://www.swrcb.ca.gov/nps/volunteer.html).

2.5.8.2 Management Practices
- Focus on the development and implementation of pollution prevention and education programs for agency staffs and the public.
- Promote assistance tools that emphasize restoration and low impact development.
- Promote projects that reduce NPS pollutants, retain or reestablish natural hydrologic regimes, and/or prevent or remedy adverse effects of hydromodification activities.

2.5.8.3 Information Resources
- Adopt-A-Stream Foundation (http://www.streamkeeper.org/): The Adopt-A-Stream Foundation, based in Washington, travels to communities around the country to provide education and outreach for students, professionals, and government officials.
- USEPA, Volunteer Stream Monitoring: A Methods Manual (http://www.epa.gov/volunteer/stream/): This guide discusses volunteer stream monitoring in terms of its role in state monitoring programs, and provides information on how to organize, implement, and maintain volunteer programs. Instream physical, chemical, and biological assessments are covered, as well as land use or watershed assessments.
- Arroyo Seco Foundation (http://www.arroyoseco.org): The Arroyo Seco Foundation works to protect and restore the Arroyo Seco watershed, which is part of the Los Angeles River watershed. The foundation also promotes environmental awareness and education.
• **Riverwatch River and Watershed Conservation Directory** ([http://www.riverwatch.org/library/libnetdirsearch.cfm](http://www.riverwatch.org/library/libnetdirsearch.cfm)): The River Network and the Rivers, Trails and Conservation Assistance Program of the National Park Service maintain this comprehensive directory, which lists over 3,600 river and watershed conservation groups, as well as local government agencies. The directory is searchable by city, state, and organization name.

• **The Council of State Governments, Getting in Step: A Guide to Effective Outreach in Your Watershed** ([http://www.epa.gov/watertrain/gettinginstep/](http://www.epa.gov/watertrain/gettinginstep)): This Web site is an online training module that provides guidance on the development of an outreach program. Downloadable worksheets are provided for use in the planning process.

• **California Regional Environmental Education Community** ([http://www.creec.org/](http://www.creec.org)): This online network is a source of environmental education resources, with links to curriculum and a statewide searchable research directory.

### 2.5.8.4 Case Study

*Urban Creeks Council Environmental Education Program.* In conjunction with hands-on projects, the Urban Creeks Council (UCC) of California works with schools and community groups to try to build a sense of stewardship for the creeks. UCC works with elementary school teachers, taking students on field trips to local creeks to learn about creek ecology, and with high school teachers, teaching students to understand how streams and rivers function, how to survey and graph creek cross sections and profiles, to conduct pebble counts, and to identify native riparian trees, shrubs, and other plants ([http://www.urbancreeks.org/Current_Programs.htm](http://www.urbancreeks.org/Current_Programs.htm)).
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2.6 **Wetlands, Riparian Areas, and Vegetated Treatment Systems**

2.6.1 **Introduction**

2.6.1.1 **Background**

The State Water Resources Control Board (SWRCB) and California Coastal Commission (CCC) have identified four management measures to protect and restore wetlands and riparian areas, and encourage the use of vegetated treatment systems as a means to control nonpoint sources of pollution. The purposes of these management measures are to promote and maintain the water quality benefits of wetland and riparian areas and to ensure that degradation does not result in nonpoint source (NPS) pollution. Associated with each management measure are management practices that are designed to promote conservation and restoration of wetlands, and reduce the quantities of pollutants entering receiving waters. The fact sheet prepared for each management measure informs readers of the programs, information resources, and case studies specific to California and the management measure.

Wetlands are vital to the survival of aquatic and terrestrial wildlife and plants. They play an important role in filtering out pollutants, preventing soil erosion, providing flow control, surface and ground water storage, aquatic and semiaquatic habitat, biological diversity, and recreation (California Resources Agency, 1998). In California, only 10 percent of the wetlands that existed prior to European settlement remain intact and only 5 percent of the coastal wetlands remain intact (California Resources Agency, 1998). Changes in hydrology, geochemistry, substrate, or species composition can impair wetland and riparian areas and reduce their ability to filter out pollutants in runoff, which can result in poor water quality in the receiving waters. Activities such as highway construction, deposition of dredged material, draining wetlands for development or cropland, hydromodification, and excavation of ports and marinas can all cause impairment of wetlands and riparian areas (USEPA, 2001).

The Plan for California’s Nonpoint Source Pollution Control Program, Volume II: California’s Management Measures for Polluted Runoff (SWRCB and CCC, 2000) defines the four management measures for wetlands, riparian areas, and vegetated treatment systems as follows:

- **6A. Protection of Wetlands and Riparian Areas.** Implementation of this management measure is intended to protect the existing water quality improvement functions of wetlands and riparian areas as a component of NPS programs.

- **6B. Restoration of Wetlands and Riparian Areas.** Restoration of wetlands and riparian areas refers to the recovery of a range of functions that existed previously by reestablishing hydrology, vegetation, and structure characteristics. Damaged or destroyed wetland and riparian areas should be restored where restoration of such systems will significantly abate polluted runoff.

- **6C. Vegetated Treatment Systems.** This management measure promotes the installation of vegetated treatment systems (e.g., artificial or constructed wetlands) in areas where these systems will serve a polluted runoff-abatement function. Vegetated filter strips and engineered wetlands remove sediment and other pollutants from runoff and wastewater, and prevent pollutants from entering adjacent water bodies. Removal typically occurs through filtration, deposition, infiltration, absorption, adsorption, decomposition, and volatilization.
• **6D. Education and Outreach.** This management measure promotes the establishment of programs to develop and disseminate scientific information on wetlands and riparian areas and to develop greater public and agency staff understanding of natural hydrologic systems—including their functions and values, how they are lost, and the choices associated with their protection and restoration.

2.6.1.2 General Resources

There are several federal programs that can provide general information to promote the protection and restoration of wetlands and riparian areas and assist with the implementation of the four management measures. The agencies and programs listed below can provide assistance and information for each wetland, riparian, and vegetated treatment system management measure. Resources specific to each of the four management measures can be found on the corresponding fact sheet.

• **California Coastal Commission's Local Assistance Program, Links to Wetlands Sites Web page** (http://www.coastal.ca.gov/la/wetland_links.htm): This is a page of Web links related to wetlands management in California and nationally.

• **California Resources Agency, California Wetlands Information System** (http://ceres.ca.gov/wetlands/): This system is a compilation of public and private sector information, including maps, environmental documents, agency roles in wetlands management, restoration and mitigation activities, regulatory permitting, and wetland policies. It is designed to provide comprehensive wetlands information to the general public, the educational community, and government agencies.

• **Coastal Conservancy and California Coastal Commission, Southern California Coastal Wetlands Inventory** (http://www.ceres.ca.gov/wetlands/geo_info/so_cal.html): The inventory consists of a database of existing information on 41 coastal wetlands that lie between Mexico and Point Conception in northern Santa Barbara County. It provides three types of information for each site: (1) a map of the wetland's historical extent, (2) a map of recent habitat distributions, and (3) a "profile" that briefly describes ecological conditions and land use and enhancement histories.

• **California Resources Agency, California Wetlands** (http://ceres.ca.gov/ceres/calweb/wetlands.html): This site contains excerpts from the Water Plan Update and a series of links to wetlands- and water resource-related Web pages.

• **Pacific Estuary Research Laboratory** (http://www.sci.sdsu.edu/PERL): The Pacific Estuary Research Laboratory was created in 1984 with funding from NOAA's Office of Coastal Zone Management, the California State Resources Agency, California State Coastal Conservancy, and San Diego State University. The site offers such resources as water quality-related reports and data, A Manual for Assessing Restored and Natural Coastal Wetlands, and other tools related to wetlands management.

• **Natural Resource Projects Inventory (NRPI)** (http://endeavor.des.ucdavis.edu/nrpi/): NRPI is a searchable comprehensive electronic database with information on thousands of conservation, mitigation and restoration projects being developed and implemented throughout California. It was developed as a collaborative effort between the California Biodiversity Council and the University of California at Davis Information Center for the Environment.
2.6.1.3 References


2.6.2 **Management Measure 6A**
**Protection of Wetlands and Riparian Areas**

**Management Measure**
Protect from adverse effects wetlands and riparian areas that serve to reduce NPS pollution; maintain this function while protecting the other existing functions of these wetlands and riparian areas as measured by characteristics such as vegetative species composition, diversity, and cover; hydrology and quality of surface water and ground water; geochemistry of the substrate; and fauna species composition, diversity, and abundance.

### 2.6.2.1 Programs
The California Resources Agency is responsible for the implementation of the State Wetlands Conservation Policy. The policy has three main goals: (1) no net loss of wetlands and a net gain of wetlands, (2) reduction in the complexity of wetland conservation laws and regulations, and (3) implementation of landowner incentive programs and cooperative planning programs. The program is divided into three geographic areas: Central Valley, San Francisco Bay, and Southern California. For more information contact Chris Potter, Coastal Grants and Wetlands Coordinator (Telephone: 916-653-5656).

Central Valley Habitat Joint Venture (CVHJV) was established in 1988 to “protect, maintain, and restore habitat to increase waterfowl populations to desired levels in the Central Valley of California consistent with other objectives of the North American Waterfowl Management Plan.” An Implementation Board of representatives from the California Waterfowl Association, Defenders of Wildlife, Ducks Unlimited, National Audubon Society, Waterfowl Habitat Owners Alliance, and The Nature Conservancy guides the CVHJV. The U.S. Fish and Wildlife Service, California Department of Fish and Game, California Department of Food and Agriculture, and other organizations and agencies provide technical assistance and advice to the Board ([http://www.usbr.gov/mp/cvhjv](http://www.usbr.gov/mp/cvhjv), [http://ceres.ca.gov/wetlands/introduction/policies_and_programs.htm](http://ceres.ca.gov/wetlands/introduction/policies_and_programs.htm)).

San Francisco Bay Conservation and Development Commission is charged with the protection and enhancement of San Francisco Bay. Protecting the Suisun Marsh and other wetlands around the bay is one of the responsibilities of the Commission ([http://www.bcdc.ca.gov/index.htm](http://www.bcdc.ca.gov/index.htm)).

Inland Wetlands Conservation Program carries out some of the Central Valley Habitat Joint Venture objectives by administering a $2-million-per-year program to acquire, improve, buy, sell, or lease wetland habitat ([http://www.dfg.ca.gov/wcb/inland_wetlands_conservation_program.htm](http://www.dfg.ca.gov/wcb/inland_wetlands_conservation_program.htm)).

CALFED Bay-Delta Program develops and implements a long-term comprehensive plan to restore ecological health and improve water management for beneficial uses of the Bay-Delta System ([http://www.calwater.ca.gov/](http://www.calwater.ca.gov/)).

Riparian Habitat Joint Venture (RHJV) has as its goal to conserve, increase, and improve riparian habitat in order to protect and enhance California's native resident birds and neotropical migratory birds. California Partners in Flight initiated the RHJV project in 1994. To date, 18 federal, state, and private organizations have signed the landmark Cooperative Agreement to protect and enhance habitats for native land birds throughout California ([http://www.prbo.org/calpif/htmldocs/rhjv/](http://www.prbo.org/calpif/htmldocs/rhjv/)).

_Last Updated July 30, 2004_
2.6.2.2 Management Practices

The purpose of this management measure is to protect the water quality improvement and NPS pollution reduction benefits derived from wetlands and riparian areas. Wetlands are characterized by a combination of standing water at the surface or root zone, unique soil conditions, and vegetation adapted to wet conditions (Mitsch and Gosselink, 1993). This management measure should combine structural and programmatic measures to protect wetland and riparian areas so that they maintain their existing functions. Recommended measures and practices include the following:

- Consider wetlands and riparian areas and their NPS control potential on a watershed or landscape and maintain their function as part of a continuum of filters along rivers, streams, and coastal waters.

- Identify existing functions of those wetlands and riparian areas with significant NPS control potential when implementing NPS management practices. Do not alter wetlands or riparian areas to improve their water quality function at the expense of their other functions.

- Do not place surface water runoff ponds or sediment retention basins in healthy wetland systems.

- Conduct permitting, licensing, certification, and nonregulatory NPS pollution abatement activities in a manner that protects wetland functions.

- Obtain easements or full acquisition rights for wetlands and riparian areas along streams, bays, and estuaries.

- Use zoning and protective ordinances to control activities that have an adverse impact on these targeted areas through special area zoning and transferable development rights.

- Ensure that State water quality standards apply to wetlands.

- Establish, maintain, and strengthen regulatory and enforcement programs.

- Encourage the use of programs that restore wetlands and riparian areas.

- Educate landowners and agencies on the role of wetlands and riparian areas in protecting water quality and on management practices for restoring stream edges.

- Provide a mechanism for private landowners and agencies in mixed ownership watersheds to develop, by consensus, goals, management plans, and appropriate practices and to obtain assistance from federal and State agencies.

- Use appropriate pretreatment practices such as vegetated treatment systems or detention or retention basins to prevent adverse impacts on wetland functions that affect the abatement of NPS pollution from hydrologic changes, sedimentation, or contaminants.

- Reduce erosion and, to the extent practicable, retain sediment onsite during and after construction.
2.6.2.3 Information Resources

**Options for Wetland Conservation: A Guide for California Land Owners**
[http://www.ceres.ca.gov/wetlands/introduction/opt_guide.html](http://www.ceres.ca.gov/wetlands/introduction/opt_guide.html): This guide describes a wide variety of approaches that have been devised to assist landowners in protecting wetlands according to their different needs, within the context of broader conservation goals. The array of options includes technical information and advice, and financial contributions for projects or practices that provide long-term improvements for wetland values. To obtain a copy, contact the California State Coastal Conservancy, 1330 Broadway Street, Suite 1100, Oakland, CA 94612 (Telephone: 510-286-1015; Fax: 510-286-0470).

**The Oregon Wetlands Conservation Guide: Voluntary Wetlands Stewardship Options for Oregon’s Private Landowners**: To obtain a copy of this guide, contact the Oregon Department of Agriculture, Natural Resources Division (Telephone: 503-292-9451).

**California Wetlands Information System** [http://ceres.ca.gov/wetlands/]: This Wetlands Information System is designed to provide comprehensive wetlands information to the general public, the educational community, and government agencies. It is a compilation of public and private sector information, including maps, environmental documents, agency roles in wetland management, restoration and mitigation activities, regulatory permitting, and wetland policies. It also includes a wetland database and inventory.

**Izaak Walton League, Handbook for Wetland Conservation and Sustainability** [http://www.iwla.org/sos/handbook/]: The Izaak Walton League put together this handbook to assist communities with planning and implementing a wetland project. The book features guidelines and tips for an effective project, monitoring techniques, case studies of other restoration projects, and extensive lists of contacts and resources.

**Managing Wetlands to Control Nonpoint Source Pollution** [http://www.epa.gov/owow/nps/facts/point11.htm]: This USEPA fact sheet, Nonpoint Pointer Number 11, includes information on the use of wetlands to control NPS pollution.

**California Resources Agency, Department of Fish and Game, Report to Legislature, California Wetland Mitigation Banking** [http://www.dfg.ca.gov/hcpb/conplan/mitbank/Wetlands Bank Leg Report Final.pdf]: This is a report to California State Congress on the progress of wetland mitigation banking in California.

**Save San Francisco Bay Association, Save The Bay Web Site** [http://www.savesfbay.org/]: Save The Bay (Save San Francisco Bay Association) seeks to preserve, restore, and protect the San Francisco Bay and Sacramento/San Joaquin Delta Estuary as healthy and biologically diverse ecosystems essential to the well-being of the human and natural communities they sustain.

2.6.2.4 Case Studies

**The Los Osos Creek Wetland Reserve**. This 144-acre site is located on Los Osos Creek, just upstream of the Morro Bay estuary. The USDA Natural Resources Conservation Service and the Coastal San Luis Resource Conservation District (CSLRC) have purchased permanent wetland reserve easements on the property. The State Coastal Conservancy provided funding for the CSLRC easement. The easements were acquired in order to return 111 acres to floodplain and riparian habitat, which will serve as a sediment deposition area, trapping sediment before it enters Morro Bay. Thirty-three acres are permanently protected in an agricultural easement. Because this is still private property, there is no public access to the site [http://www.coastalrcd.org/].
California’s Big River Becomes a State Park. A 50-mile stretch of California's Big River, along with 1,500 acres of the State's remaining coastal wetlands became a State park in August 2002. For years, the swath of redwoods belonged to timber companies. Now, the wildlife habitat will be protected, as will an 8.3-mile estuary—the longest undeveloped estuary in Northern California. The deal encompasses 12 miles of prime coho and steelhead salmon spawning grounds. More than 130 species of birds live there. The Big River, which gets its name from the towering trees along its banks, is also home to river otters, beavers, and harbor seals (http://www.amrivers.org/rivercurrents/080902.htm).

2.6.2.5 References


2.6.3 Management Measure 6B
Restoration of Wetlands and Riparian Areas

Promote the restoration of the preexisting functions in damaged and destroyed wetlands and riparian systems in areas where the systems will serve to reduce NPS pollution.

2.6.3.1 Programs
Southern California Wetlands Recovery Project is a partnership of public agencies working cooperatively to acquire, restore, and enhance coastal wetlands and watersheds between Point Conception and the international border with Mexico (http://www.coastalconservancy.ca.gov/scwrp/). The Southern California Wetlands Recovery Project is also building a dynamic information system to help collect and distribute data, resources, and other information on Southern California's coastal wetlands and coastal watersheds (http://eureka.regis.berkeley.edu/wrpinfo/).

The San Francisco Bay Joint Venture (SFBJV) is a partnership that brings together public and private agencies, conservation groups, development interests, and others seeking to collaborate in restoring wetlands and wildlife habitat specifically within the San Francisco Bay watersheds and along the San Mateo Coast (http://www.sfbayjv.org/).

CALFED Bay-Delta Program ecosystem restoration actions under the CALFED Bay-Delta Program help restore and improve the health of the Bay-Delta system for all native species while reducing its water management constraints (http://www.calwater.ca.gov/Programs/EcosystemRestoration/Ecosystem.shtml).

U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS), California Wetlands Reserve Program has focused on the restoration of a variety of wetland types throughout the State, including seasonal wetlands, semi-permanent marsh, vernal pools along the perimeter of the Central Valley, riparian corridors, and tidally influenced wetlands (http://www.nrcs.usda.gov/programs/wrp/states/ca.html).

California Department of Transportation (Caltrans) abides by the no-net loss requirement for California wetlands and is responsible for creating, restoring, or enhancing wetlands or riparian areas damaged or destroyed by highway projects (http://www.dot.ca.gov/hq/env/bio/index.htm).

Ballona Wetlands Foundation was created by a court action to preserve and protect the remaining Ballona Wetlands on California's coast near Los Angeles. The foundation is responsible for implementing and managing a comprehensive restoration plan for the wetlands (http://www.ballona-wetlands.org/).

2.6.3.2 Management Practices
The purpose of this management measure is to promote the restoration of degraded or destroyed wetlands in areas where they can reduce NPS pollution. Restoration of a wetland and a riparian area means reestablishing the existing vegetation, hydrology, and structure characteristics. This management measure should be used in conjunction with other measures addressing the adjacent land use activities, like agriculture, urban areas, marinas, and forestry. Recommended practices and measures for promoting the restoration of riparian areas and wetlands include the following:

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• Provide a hydrologic regime similar to that of the type of wetland or riparian area being restored.

• Identify important information such as site history, topography, tides, existing water control structures, hydrology, sediment budgets, soil, plants, salinity, timing of the restoration project, and potential impacts from adjacent human activities, before beginning a restoration project.

• Restore native plant species through either natural succession or selected planting.

• Plant a diversity of species or manage the natural succession of diverse plant species rather than planting monocultures.

• Plan restoration as part of naturally occurring aquatic ecosystems.

• Factor in ecological principles when selecting sites and designing restoration. Consider type and quantity of pollutant, slope, and vegetated area.

2.6.3.3 Information Resources

Stream Corridor Restoration (http://www.usda.gov/stream_restoration/): This document was produced by the collective experience, skills, and technology of 15 federal agencies. It is a benchmark document that is being used by these agencies, as well as many others who are interested in restoring the functions and values of the nation's stream corridors.

Caltrans, Standard Environmental Reference, Chapter 5: Mitigation and Monitoring (http://www.dot.ca.gov/ser/vol3/chap5.htm): This chapter provides guidance on mitigation activities used to compensate for the loss of wetlands due to transportation activities.

Tennessee Hollow Restoration Project (http://www.shadesofgreen.bizland.com/tennhollow01 chois): This site offers a detailed look at the proposed plan to restore Tennessee Hollow Creek, one of two streams in San Francisco that have not been completely buried and built over with tall structures. The site offers a detailed report that describes the efforts of the Urban Watershed Project to restore the watershed.

Orange County Coastkeeper (http://www.coastkeeper.org/): The mission of the Orange County Coastkeeper, a nonprofit environmental activist organization, is to protect and preserve Orange County's marine habitat and watershed through education, restoration, and enforcement.

USDA Forest Service, Sierra Nevada Research Center (http://www.psw.fs.fed.us/snrc/research_emphasis_areas/aquatic/aquatic.html): The Aquatic, Riparian and Wetland Ecology Group focuses on the response of populations and communities of aquatic and riparian-associated species to natural and anthropogenic influences, such as introduced exotic species, natural and regulated stream flow regimes, livestock grazing, natural and prescribed fire, and vegetation management.

USEPA, River Corridor and Wetland Restoration (http://www.epa.gov/owow/wetlands/restore/): This Web site features information on restoration techniques, the benefits of restoration, information resources, and links.
2.6.3.4 Case Studies

Wetland Reserve Program Success Story. In 1989, Yolo County realtor Jeff Dyer purchased 98 acres of marginal farmland east of Zamora, California. The land had previously been used to grow rice, tomatoes, and other crops, but the heavy alkaline clay soil made farming conditions less than ideal. Dyer farmed part of the land, but he had other plans for a large portion of the property. He wanted to restore a wetland.

In 1999, with assistance provided under USDA’s Wetland Reserve Program (WRP), Dyer successfully restored 34 acres of seasonal marsh through a 30-year WRP easement. USDA NRCS assisted Dyer with the excavation work necessary to restore the natural hydrology of the property and improve habitat for wetland-dependent wildlife. The work included construction of shallow water areas, levees, and water-control structures. Excavation spoil was used to build levees and create islands in two of the ponds. Dyer established and maintains a variety of wetland plants and perennial vegetation that reduce soil erosion and sedimentation, improve water quality, and provide habitat for wildlife. He also installed a pump to control the water level for brood pond areas and resident waterfowl (http://www.nrcs.usda.gov/programs/wrp/states/success_ca.htm).

Palomares Creek Streambank Restoration Project. The Palomares Stream Restoration Project is a joint effort by the Conservation Partnership and Alameda County Flood Control and Water Conservation District to illustrate alternative (soft) stream restoration practices. The project consists of 300 linear feet of bank protection and restoration along Palomares Creek at Palomares Elementary School near Castro Valley, California. The project demonstrates four different techniques in riparian restoration. At the most downstream reach, a live (vegetated) crib wall has been constructed. At a large curve in the creek, toe rock has been installed. The toe rock extends into the middle reach of the root wad revetment. Lastly, at an extreme bend in an upper reach of the creek, rock riprap with joint plantings has been installed. Native vegetation will be replanted in and around the bank protection structures (http://www.baysavers.org/projects/SanLorenzo/Palomares/palstreambank.html).

2.6.3.5 References

2.6.4 Management Measure 6C
Vegetated Treatment Systems

Management Measure
Promote the use of engineered vegetated treatment systems such as constructed wetlands or vegetated filter strips where these systems will serve to reduce NPS pollution.

2.6.4.1 Programs
The Sacramento Constructed Wetlands Demonstration Project is a 5-year project of the Sacramento Regional County Sanitation District that was conducted from January 1994 to December 1998. The emphasis of the project was on describing how treatment wetlands remove trace metals (http://www.srcsd.com/cw.html).

California Buffer Initiative is an effort to encourage farmers, ranchers, and other landowners to use conservation buffers more extensively for a variety of conservation purposes (http://www.ca.nrcs.usda.gov/programs/buffer.html).

2.6.4.2 Management Practices
The practices listed below should be used where engineered systems of wetlands or vegetated treatment systems can treat NPS pollution. Vegetated treatment systems can be placed in upland regions and protect wetlands and aquatic resources from NPS pollution. For the purposes of this management measure, vegetated treatment systems are vegetated filter strips and constructed wetlands. Recommendations for installing and using vegetated treatment systems are as follows:

- Install vegetated filter strips to remove sediment and other pollutants from runoff and wastewater.
- Construct vegetated filter strips in areas adjacent to water bodies that may be subject to suspended solids and/or nutrient runoff. Key elements to be considered in the design of such areas include the type and quantity of pollutant, slope, native/non-native species, length, detention time, monitoring performance, and maintenance.
- Use vegetated filter strips to improve urban environments by increasing wildlife habitat and adding beauty to an area.
- Construct properly engineered systems of wetlands for NPS pollution control. Several factors to consider in the design and construction of an artificial wetland include hydrology, soils, vegetation, influent water quality, geometry, pretreatment, and maintenance.
- Manage constructed wetland systems to avoid negative impacts on surrounding ecosystems or ground water.
2.6.4.3 Information Resources

Sustainable Conservation, Wastewater to Wetlands: Opportunities for California Agriculture (http://www.suscon.org/wetlands/pdfs/feasibility.pdf): This guidebook describes the use of wetlands to control pollutants in wastewater from agriculture.

Broome, S.W., Constructed Wetlands for the Treatment of Storm Water Runoff (http://www.soil.ncsu.edu/lockers/Broome_S/vmmiller/stormwater.htm): This article provides information on using wetlands to treat storm water runoff.

USEPA, Guiding Principles for Constructed Treatment Wetlands: Providing for Water Quality and Wildlife Habitat (http://www.epa.gov/owow/wetlands/constructed/guide.htm): This guidebook presents guiding principles for siting, design, construction, operation, maintenance, and monitoring of constructed treatment wetlands.

USEPA, Handbook of Constructed Wetlands (http://www.epa.gov/owow/wetlands/pdf/hand.pdf): This is a guide to creating wetlands for agricultural wastewater, domestic wastewater, coal mine drainage, and storm water in the Mid-Atlantic Region.

USDA, Constructed Wetlands Bibliography (http://www.nal.usda.gov/wqic/Constructed_Wetlands_all/index.html): This constructed wetlands bibliography, compiled by the Natural Resources Conservation Service and the Water Quality Information Center at the National Agricultural Library, consists of more than 600 citations.

USDA NRCS, Conservation Buffers Initiative (http://www.nrcs.usda.gov/feature/buffers/): This Web site provides information on buffers, their use, and technology specifications. It describes success stories and provides links for more information.

2.6.4.4 Case Study

The Orange County Water District Constructed Wetlands Project. The Orange County Water District owns 2,150 acres behind Prado Dam in Riverside County, California. Within this area lie nearly 465 acres of constructed wetlands, which have effectively demonstrated the ability to reduce nitrogen levels in Santa Ana River. The Santa Ana River is the main source of recharge for the vast Orange County ground water basin, and consists primarily of tertiary treated wastewater from upstream dischargers. The river also receives storm flows, natural runoff, and rising ground water, especially during winter months.

The wetland consists of a system of 50 shallow ponds that have been used to remove nitrogen in river water since July 1992. The wetland system removes approximately 20 tons of nitrate a month, and during summer months reduces nitrate concentrations from 10 milligrams per liter to less than 1 milligram per liter. Several modifications have been made to increase the hydraulic capacity of the Prado wetland pond system, in order to handle a potential increase in future baseflows from the Santa Ana River, and to improve the operational flexibility of the system.

Prado Dam is a key component for increasing local water supplies in Orange County. Historically, storm flows from the Santa Ana River have been lost to the ocean because flood control took precedence over water conservation. However, a series of agreements between Orange County Water District, the U.S. Army Corps of Engineers, and the U.S. Fish and Wildlife Service have allowed the District to conserve water behind the dam in a seasonal storage pool. (http://www.ocwd.com/_html/prado.htm)
2.6.4.5 Reference

2.6.5 Management Measure 6D
Education/Outreach

Management Measure

Implement educational programs to provide greater understanding of watersheds, to raise awareness and increase the use of applicable management measures and practices for wetlands and riparian areas, and to promote projects that retain or reestablish natural hydrologic functions. Public education, outreach, and training programs should involve user groups and the community.

2.6.5.1 Programs

Lake Tahoe Environmental Education Coalition (LTEEC) provides assistance to many different groups and educational organizations with educating the public about how to prevent pollution of Lake Tahoe. The University of Nevada Cooperative Extension and the University of California Cooperative Extension sponsor LTEEC (http://www.lteec.org/working_groups.php?groupID=2).

Orange County Watershed and Coastal Resources Division is progressively developing materials to better inform the public about the services that are provided. It also offers and encourages ways for the public to get involved (http://www.ocwatersheds.com/PublicEducation/pe_introduction.asp).

Adopt-A-Watershed is a K-12 school-community learning experience. Adopt-A-Watershed uses a local watershed as a living laboratory in which students engage in hands-on activities, making science applicable and relevant to their lives. It develops collaborative partnerships and reinforces learning through community service (http://www.adopt-a-watershed.org/index.html).

2.6.5.2 Management Practices

The purpose of this management measure is to promote the establishment of programs to develop and disseminate scientific information on wetlands and riparian areas. Recommended practices include the following:

- Develop fact sheets, brochures, and flyers on the importance of wetlands and riparian areas.
- Develop greater public and agency staff understanding of natural hydrologic systems—including their functions and values, how they are lost, and the choices associated with their protection and restoration.
- Work with private landowners to encourage the preservation of wetland and riparian areas.
- Develop education programs for grade school children.
- Promote restoration of degraded wetland and riparian areas by volunteer and community groups.
2.6.5.3 Information Resources


The California Coastal Commission's New Science Activity Guide: Waves, Wetlands, and Watersheds ([http://www.coastal.ca.gov/publiced/pendx.htm](http://www.coastal.ca.gov/publiced/pendx.htm)): This is a classroom and community activity guide that addresses issues such as endangered species, marine debris, coastal geology, water use, and much more. It is carefully aligned to the California State Science Content Standards for grades 3 through 8, and includes “Community Action” lessons adaptable to all ages up to and beyond grade 12. The guide is available for free from the California Coastal Commission.

Watershed Institute ([http://watershed.csumb.edu/index.htm](http://watershed.csumb.edu/index.htm)): The Watershed Institute consists of a direct action community-based coalition of researchers, restoration ecologists, educators, planners, students, and volunteers. These participants all work to promote and employ a systems approach to the management of watersheds around the world.

The Return of the Natives Restoration Education Project ([http://watershed.csumb.edu/ron/](http://watershed.csumb.edu/ron/)): The Return of the Natives (RON) Restoration Education Project is a project of Creative Environmental Conservation, a 501(c)3 nonprofit. It is the education and outreach branch of the Watershed Institute of the California State University Monterey Bay. RON is a community- and school-based environmental education project dedicated to involving students (kindergarten through university) in native plant and habitat restoration projects in the schoolyard and the community.

2.6.5.4 Case Study

*Upper Newport Bay Project, Community-Based Restoration and Wetland Education Program.* The California Coastal Commission’s Upper Newport Bay (UNB) Community-Based Restoration Education Program is working to enlist community support for habitat restoration by engaging the public in hands-on restoration work and teaching them why this work is important. The program grew out of the Coastal Commission’s successful public involvement efforts. The Commission’s programs use a tried and true formula: collaborate with local organizations working in ecology, education, and conservation, and provide the leadership, planning, and funding to help connect volunteers and neighborhood groups with the affected ecosystem. The UNB program will serve as a model for developing coastal restoration education programs throughout California ([http://www.coastal.ca.gov/publiced/restore.htm](http://www.coastal.ca.gov/publiced/restore.htm)).

*Yolo Basin Foundation, Discover the Flyway Program.* The Discover the Flyway (DTF) program for schools serves more than 2,500 students annually. The purpose of this program is to introduce Central Valley area teachers to wetland ecosystems and encourage class visits to the Vic Fazio Yolo Wildlife Area so they may participate in educational and interactive field studies. The DTF program includes teacher workshops, the Wild About Wetlands classroom resource kit, a lending library, classroom field trips, native grass/sedge restoration, Nature Bowl, Marsh Madness, and the Yolo Demonstration Wetlands ([http://www.yolobasin.org/education.html](http://www.yolobasin.org/education.html)).
3. **Funding Resources**

The following are Web sites that can be helpful in tracking down information about funds available to implement NPS pollution projects and programs:

- **SWRCB, Financial Assistance** ([http://www.swrcb.ca.gov/funding/](http://www.swrcb.ca.gov/funding/)): This Web site provides links to numerous funding resources for projects and programs related to water quality protection and improvement. Topics include Propositions 13, 40, and 50; Clean Water Act Section 319 funding; the Clean Water State Revolving Fund; and local and subject-specific programs.

- **USEPA, Funding for Nonpoint Source Pollution** ([http://www.epa.gov/owow/nps/funding.html](http://www.epa.gov/owow/nps/funding.html)): This site contains numerous links to resources that are specifically geared toward addressing NPS pollution problems. Both USEPA and non-USEPA sites are included.

- **USEPA, Catalog of Federal Funding Sources for Watershed Protection** ([http://cfpub.epa.gov/fedfund/](http://cfpub.epa.gov/fedfund/)): This Web site provides a comprehensive summary of federal grant and loan programs that be used at the local level to support watershed projects. Also contains references to other publications as well as web sites on funding assistance.

- **USEPA, A State and Local Government Guide to Environmental Program Funding Alternatives** ([http://www.epa.gov/owow/nps/MMGI/funding.html](http://www.epa.gov/owow/nps/MMGI/funding.html)): This document provides an overview of traditional (nongovernmental) funding mechanisms and innovative approaches for funding environmental programs.

- **USEPA, Clean Water Financing** ([http://www.epa.gov/OWM/cwfinance/index.htm](http://www.epa.gov/OWM/cwfinance/index.htm)): This Web site provides links with more information about the Clean Water State Revolving Fund, the Construction Grants Program, Water Pollution Control Program Grants, Water Quality Cooperative Agreements, Clean Water Indian Program Grants, and assistance with privatization of wastewater facilities.

- **USEPA, Environmental Finance Program** ([http://www.epa.gov/efinpage/](http://www.epa.gov/efinpage/)): The goal of this program is to assist communities in their search for creative approaches to funding their environmental projects. The program provides financial technical assistance to the regulated community and solicits advice and recommendations to the Agency on environmental finance issues, trends, and options. The Environmental Financial Tools Web page ([http://www.epa.gov/efinpage/efptools.htm](http://www.epa.gov/efinpage/efptools.htm)) provides continuously updated links to sources of financing from the Environmental Finance Program, USEPA programs and offices, and organizations outside the agency.

- **USDA Water Quality Information Center, Funding Sources for Water Quality** ([http://www.nal.usda.gov/wqic/funding.html](http://www.nal.usda.gov/wqic/funding.html)): For information on water quality funding sources beyond EPA's programs including funding from USDA, the U.S. Department of Interior, NOAA, the Federal Highway Administration, and USGS.
- **U.S. General Services Administration, The Catalog of Federal Domestic Assistance** ([http://12.46.245.173/cfda/cfda.html](http://12.46.245.173/cfda/cfda.html)). Click “Search for Assistance Programs” and browse “By Functional Area” to select “Environmental Quality,” which yields the following choices relevant to NPS pollution: water pollution control; solid waste management; pesticides control; and research, education, and training.

- **USEPA, Drinking Water State Revolving Fund** ([http://www.epa.gov/safewater/dwsrf.html](http://www.epa.gov/safewater/dwsrf.html)): This Web site provides guidance, fact sheets and reports, program data, and information about programs related to the Drinking Water State Revolving Fund. Funds from this program are to be used to finance drinking water infrastructure improvements. Emphasis is placed on funds to small and disadvantaged communities and to programs that encourage pollution prevention.
## 4. List of Acronyms

### A

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACCWP</td>
<td>Alameda Countywide Clean Water Program</td>
</tr>
<tr>
<td>AMBAG</td>
<td>Association of Monterey Bay Area Governments</td>
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</tbody>
</table>

### B

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>BAER</td>
<td>Burned Area Emergency Rehabilitation</td>
</tr>
<tr>
<td>BEAR</td>
<td>Beach Erosion and Response</td>
</tr>
<tr>
<td>BIFS</td>
<td>Biologically Integrated Farming Systems</td>
</tr>
<tr>
<td>BLM</td>
<td>Bureau of Land Management</td>
</tr>
<tr>
<td>BMP</td>
<td>Best Management Practice</td>
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</tbody>
</table>

### C

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>CALFED</td>
<td>California Bay-Delta Authority</td>
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<tr>
<td>CalOCEAN</td>
<td>California Ocean and Coastal Environmental Access Network</td>
</tr>
<tr>
<td>CalPIF</td>
<td>California Partners in Flight</td>
</tr>
<tr>
<td>CAMMPR</td>
<td>California’s Management Measures for Polluted Runoff</td>
</tr>
<tr>
<td>CCA</td>
<td>Certified Crop Advisors</td>
</tr>
<tr>
<td>CCC</td>
<td>California Coastal Commission</td>
</tr>
<tr>
<td>CCVT</td>
<td>Central Coast Vineyard Team</td>
</tr>
<tr>
<td>CDF</td>
<td>California Department of Forestry and Fire Protection</td>
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<tr>
<td>CDP</td>
<td>Coastal Development Permits</td>
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<tr>
<td>CDQA</td>
<td>California Dairy Quality Assurance</td>
</tr>
<tr>
<td>CEQA</td>
<td>California Environmental Quality Act</td>
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<tr>
<td>CERES</td>
<td>California Environmental Resources Evaluation System</td>
</tr>
<tr>
<td>CERPI</td>
<td>California Ecological Restoration Projects Inventory</td>
</tr>
<tr>
<td>CFIP</td>
<td>California Forest Improvement Program</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>CIMIS</td>
<td>California Irrigation Management Information System</td>
</tr>
<tr>
<td>CIWMB</td>
<td>California Integrated Waste Management Board</td>
</tr>
<tr>
<td>CMS</td>
<td>Conservation Management System</td>
</tr>
<tr>
<td>CNMP</td>
<td>Comprehensive Nutrient Management Plan</td>
</tr>
<tr>
<td>COWA</td>
<td>California Onsite Wastewater Association</td>
</tr>
<tr>
<td>CSLRCD</td>
<td>Coastal San Luis Resource Conservation District</td>
</tr>
<tr>
<td>CURES</td>
<td>Coalition for Urban/Rural Environmental Stewardship</td>
</tr>
<tr>
<td>CVHJV</td>
<td>Central Valley Habitat Joint Venture</td>
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<tr>
<td>CWA</td>
<td>Clean Water Act</td>
</tr>
<tr>
<td>CWE</td>
<td>Cumulative Watershed Effects</td>
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<tr>
<td>CWT</td>
<td>Clean Water Team</td>
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<tr>
<td>CWTRC</td>
<td>California Wastewater Training and Research Center</td>
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</tbody>
</table>
**California Nonpoint Source Encyclopedia**  

**List of Acronyms**

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<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>CZARA</td>
<td>Coastal Zone Act Reauthorization Amendments</td>
</tr>
<tr>
<td>CZMA</td>
<td>Coastal Zone Management Act</td>
</tr>
<tr>
<td>DBW</td>
<td>Department of Boating and Waterways</td>
</tr>
<tr>
<td>DEP</td>
<td>Department of Environmental Protection</td>
</tr>
<tr>
<td>DFG</td>
<td>Department of Fish and Game</td>
</tr>
<tr>
<td>DPR</td>
<td>Department of Pesticide Regulation</td>
</tr>
<tr>
<td>DTF</td>
<td>Discover the Flyway</td>
</tr>
<tr>
<td>DTSC</td>
<td>Department of Toxic Substance Control</td>
</tr>
<tr>
<td>EAO</td>
<td>Environmental Assistance Office</td>
</tr>
<tr>
<td>EISIP</td>
<td>Expanded Irrigation System Improvement Program</td>
</tr>
<tr>
<td>ELZ</td>
<td>Equipment Limitation Zone</td>
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<tr>
<td>ESC</td>
<td>Erosion and Sediment Control</td>
</tr>
<tr>
<td>ESHA</td>
<td>Environmentally Sensitive habitat Area</td>
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<tr>
<td>ETI</td>
<td>Environmental Technology Initiative</td>
</tr>
<tr>
<td>ETV</td>
<td>Environmental Technology Verification</td>
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<tr>
<td>FHP</td>
<td>Forest Health Protection</td>
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<tr>
<td>FIP</td>
<td>Forestry Incentives Program</td>
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<tr>
<td>FOTG</td>
<td>Field Office Technical Guides</td>
</tr>
<tr>
<td>FRAP</td>
<td>Fire and Resource Assessment Program</td>
</tr>
<tr>
<td>FSCBG</td>
<td>Forest Service Cramer-Barry-Grim</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<tr>
<td>GLCI</td>
<td>Grazing Land Conservation Initiative</td>
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<tr>
<td>IPM</td>
<td>Integrated Pest Management</td>
</tr>
<tr>
<td>ITE</td>
<td>Institute of Transportation Engineers</td>
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<tr>
<td>I</td>
<td>Institute of Transportation Engineers</td>
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<tr>
<td>LCP</td>
<td>Institute of Transportation Engineers</td>
</tr>
<tr>
<td>LTEEC</td>
<td>Lake Tahoe Environmental Education Coalition</td>
</tr>
<tr>
<td>LWWL</td>
<td>Lake Tahoe Environmental Education Coalition</td>
</tr>
<tr>
<td>MARPOL</td>
<td>Protocol from the International Convention for the Prevention of Pollution from Ships</td>
</tr>
<tr>
<td>MPA</td>
<td>McAttee-Petris Act</td>
</tr>
<tr>
<td>MS4</td>
<td>Municipal Separate Storm Sewer System</td>
</tr>
<tr>
<td>MSD</td>
<td>Marine Sanitation Device</td>
</tr>
<tr>
<td>MURP</td>
<td>Model Urban Runoff Program</td>
</tr>
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*Last Updated July 30, 2004*
List of Acronyms

N
NDIP  North Delta Improvements Project
NEMO  Nonpoint Education for Municipal Officials
NEPA  National Environmental Policy Act
NF   National Forest
NFMA  National Forest Management Act
NIPC  Northeastern Illinois Planning Commission
NIPMN  National Integrated Pest Management Network
NIWQP  National Irrigation Water Quality Program
NMP  Nutrient Management Plan
NOAA  National Oceanic and Atmospheric Administration
NPDES  National Pollutant Discharge Elimination System
NRCS  Natural Resources Conservation Service
NRPI  Natural Resource Project Inventory
NWRC  National Wetlands Research Center

P
P2  Pollution Prevention
PAM  Polyacrylamide
PCA  Pest Control Advisors
PPIC  Pollution Prevention Information Clearinghouse
PPS  Positive Points System
PRC  Public Resources Code

Q
QA  Quality Assurance
QC  Quality Control

R
RCD  Resource Conservation Districts
RHJV  Riparian Habitat Joint Venture
RMS  Resource Management Systems
RON  Return of the Natives
RPF  Registered Professional Forester
RWQCB  Regional Water Quality Control Board

S
SbMA  Subdivision Map Act
SDIP  South Delta Improvements Program
SFBJV  San Francisco Bay Joint Venture
SMA  Streamside Management Areas
SMZ  Streamside Management Zones
SRF  State Revolving Fund
STOPPP  San Mateo Countwide Stormwater Pollution Prevention Program
STPP  Surface Transportation Policy Project
SUSMMP  Standard Urban Storm Water Mitigation Plan
SWPPP  Storm Water Pollution Prevention Plan
SWRCB  State Water Resources Control Board

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### List of Acronyms

**T**
- THP: Timber Harvest Plan
- TMDL: Total Maximum Daily Load
- TRM: Turf Reinforcement Mat
- TSS: Total Suspended Solids

**U**
- UCC: Urban Creeks Council
- UNB: Upper Newport Bay
- USACE: United States Army Corps of Engineers
- USC: United States Code
- USDA: United States Department of Agriculture
- USEPA: United States Environmental Protection Agency

**V**
- VMP: Vegetation Management Program

**W**
- WDR: Waste Discharge Requirements
- WITS: Watershed Information Technical System
- WLPZ: Watercourse and Lake Protection Zones
- WRP: Wetland Reserve Program
- WSDOT: Washington State Department of Transportation
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Californians Without Safe Water: A 2005 Update
By Monique Wilber

Article Pending
Water Quality, California, 2004
Written and edited by John Andrew, DWR
In this paper, DWR has consolidated in one place the major water quality sections from the various volumes of this California Water Plan Update. To start, it presents an overview of the legal and regulatory framework for protecting water quality, then discusses statewide water quality issues of concern, and concludes with regional profiles of water quality issues around California. It also includes a section describing the Water Boards and their role in water quality, which is not found elsewhere in Bulletin 160, California Water Plan Update 2005. Most of the other information, though, is excerpted from this California Water Plan Update, with editing only for context and clarity.

**Legal and Regulatory Framework for Protecting Water Quality**  
(excerpted from “Water Allocation, Use, and Regulation in California,” Volume 4)

**Clean Water Act-National Pollutant Discharge Elimination System**

Section 402 of the Clean Water Act established a permit system, the National Pollutant Discharge Elimination System (NPDES), to regulate point sources of discharges in navigable waters of the United States. U.S. Environmental Protection Agency (EPA) was given the authority to implement the NPDES, although the act also authorizes states to implement the NPDES program in lieu of the USEPA, provided the State has sufficient authority.

After the Clean Water Act was enacted in 1972, USEPA and the states focused primarily on implementing technology-based controls for “point” sources, which, for example, are discharges from pipes from factories and municipal sewage treatment plants. Today, those controls are largely in place, and the focus is beginning to shift to “non-point source” pollution, such as runoff from cities and farms.

**Porter-Cologne Water Quality Control Act**

The Porter-Cologne Water Quality Control Act is California's comprehensive water quality control law and is a complete regulatory program designed to protect water quality and beneficial uses of the state's water. It requires the adoption of water quality control plans (basin plans) by the State's nine Regional Water Quality Control Boards (Regional Water Boards) for watersheds within their regions. The basin plans are reviewed triennially and amended as necessary by the Regional Water Boards, subject to the approval of the California Office of Administrative Law, the State Water Board and ultimately the federal EPA. Moreover, pursuant to Porter-Cologne, these basin plans shall become part of the California Water Plan, when such plans have been reported to the Legislature (Section 13141, California Water Code).

In 1972, the Legislature amended the Porter-Cologne Act to give California the authority and ability to operate the federal NPDES permits program. Before a permit may be issued, Section 401 of the Clean Water Act requires that the Regional Water Quality Control Board (RWQCB) certify that the discharge will comply with applicable water quality standards. In addition, under Porter-Cologne, the RWQCB may

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1 The author recognizes and thanks Loren Bottorff for his thoughtful comments and edits on these various water quality sections.
also issue waste discharge requirements, that set conditions on the discharge of a waste. These requirements must be consistent with the water quality control plan for the body of water that receives the waste discharge, as well as protect the beneficial uses of those receiving waters.

The Regional Water Boards also implement Section 402 of the federal Clean Water Act, which allows the State to issue a single discharge permit for stormwater runoff for the purposes of both State and federal law.

**Federal Safe Drinking Water Act**

The Safe Drinking Water Act (SDWA), enacted in 1974 and significantly amended in 1986 and 1996, directed the USEPA to set national standards for drinking water quality. It required the USEPA to set maximum contaminant levels for a wide variety of constituents. Local water suppliers are required to monitor their water supplies to assure that regulatory standards are not exceeded.

A Maximum Contaminant Level (MCL) is the maximum concentration of a contaminant that is allowed in public drinking water systems. The 1986 amendments set a timetable for the USEPA to establish standards for specific contaminants and increased the range of contaminants local water suppliers were required to monitor to include contaminants that did not yet have an MCL established. The 1986 Safe Drinking Water Act Amendments also led to the USEPA’s adoption of the Surface Water Treatment Rule, which addresses filtration and disinfection of surface waters. The amendments included a wellhead protection program, a grant program for designating sole-source aquifers for special protection, and grant programs and technical and financial assistance to small systems and states.

The 1996 amendments included stronger regulation of microbial contaminants, such as Cryptosporidium, while managing levels of disinfection byproducts, source water assessment programs, and establishment of a drinking water state revolving fund. The source water assessment and protection programs offer tools and opportunities to build a prevention barrier to drinking water contamination. Under the Safe Drinking Water Act, the state is required to develop comprehensive Source Water Assessment Programs that will identify the areas that supply public tap water, inventory contaminants and assess water system susceptibility to contamination, and inform the public of the results.

For every new standard, USEPA conducts an analysis to determine if the benefits of the standard justify the costs. If not, USEPA may adjust the MCL to a level that “maximizes the health risk reduction benefits at a cost that is justified by the benefits.”

**California Safe Drinking Water Act**

In 1976, California enacted its own Safe Drinking Water Act, requiring the Department of Health Services (DHS) to regulate drinking water, including: setting and enforcing federal and State drinking water standards; administering water quality testing programs; and administering permits for public water system operations. In 1989, significant amendments to the California act incorporated the new federal safe drinking water act requirements into California law, gave DHS discretion to set more stringent MCLs, and recommended public health levels for contaminants.
California Government

Beyond DWR, many State departments and agencies oversee California's water quality. For example, the State Water Board integrates water rights and water quality decision-making authority. The State Water Board and the nine Regional Water Boards are responsible for protecting California’s water resources. Other State agencies and their roles in water quality management follow:

- California Bay-Delta Authority—Oversees the 23 State and federal agencies working cooperatively through the CALFED Bay-Delta Program to improve the quality and reliability of California’s water supplies while restoring the Bay-Delta ecosystem.
- California Environmental Protection Agency—Restores, protects, and enhances the environment to ensure public health, environmental quality, and economic vitality.
- California Integrated Waste Management Board—Manages the estimated 76 million tons of waste generated each year by reducing waste whenever possible, promoting the management of all materials to their highest and best use, and protecting public health and safety and the environment.
- Department of Fish and Game—Regulates and conserves the state’s wildlife.
- Department of Food and Agriculture—Supports California’s agricultural economy.
- Department of Health Services—Oversees programs to protect and improve the health of all Californians, regulates and permits drinking water.
- Department of Pesticide Regulation—Regulates pesticide sales and use and plays a significant role in monitoring for the presence of pesticides and in preventing further contamination of the water resource.
- Department of Toxic Substances Control—Provides technical oversight for the characterization and remediation of soil and water contamination.

Federal Government

The federal government also has an important role in protecting the state’s water quality, particularly the USEPA, which protects human health and the natural environment. Other federal agencies with water quality roles include:

- U.S. Army Corps of Engineers—Plans, designs, builds, operates, and regulates water resources projects (e.g., navigation, flood control, environmental protection, disaster response). The Corps is also responsible for 404 dredge and fill permits that will then result in a need for Regional Water Board water quality certification.
- U.S. Bureau of Reclamation—Constructs federal water supply projects and is the nation’s largest wholesaler of water and the second largest producer of hydroelectric power.
- U.S. Department of Agriculture (USDA)—Manages forests, watersheds, and other natural resources.
- Natural Resource Conservation Service (within USDA)—Provides technical and financial assistance to conserve, maintain and improve natural resources on private lands.
- U.S. Fish and Wildlife Service—Conserves, protects, and enhances fish, wildlife, and plants and their habitats.
- U.S. Geological Survey—Provides water measurement and water quality research.
Public Agencies, Districts, and Local Governments

Local city and county governments and special districts have ultimate responsibility for providing safe and reliable water to their customers. Cities and counties, which may also provide domestic water, are also the land and resource management agencies and planning entities that most influence the location and amount of population growth within the state.

Private Entities

In addition to public agencies, private entities may also supply water. Mutual water companies, for example, are private corporations that perform water supply and distribution functions similar to public water districts. Sometimes investor-owned utilities are also involved in water supply activities as an adjunct of hydroelectric power development. These investor-owned water companies are regulated by the California Public Utilities Commission.

Individual Water Users

Collectively, the millions of urban businesses, individual households, and farms fund the operation and maintenance of California’s water systems through payment of taxes and water bills. Each makes decisions on water use and conservation for its own circumstances. Individual water users must dispose of used water, usually through a sewer or gutter, which in turn can create water pollution. This return flow can provide water to downstream water users. During drought periods, many households modify outdoor watering to conserve water. Each year, farmers make decisions on planting and water application based on weather conditions, forecasted water supply, and individual tolerance for market risk. Taken together, these individual decisions about water use have an enormous impact on both water demand and water quality and present many opportunities for individuals to play positive roles in better managing California’s water quantity and quality.

Water Quality and the Water Boards

Water is California’s most precious resource, providing an essential lifeline between agriculture, industry, the environment and urban and rural interests throughout the state. With a growing population of more than 30 million and a limited supply of fresh water, the protection of water for beneficial uses is of paramount concern for all Californians. The State Water Board and the Regional Water Boards, under the umbrella of the California Environmental Protection Agency, are responsible for protecting California’s water resources.

Created by the Dickey Water Pollution Act, the Regional Water Boards have been responsible for protecting the surface, ground and coastal waters of their regions since 1949. In 1967, the State Water Rights Board and the State Water Quality Control Board were merged to create the State Water Resources Control Board, integrating water rights and water quality decision-making authority. The nine Regional Water Boards are semi-autonomous and comprised of up to nine part-time board members appointed by the governor. Regional boundaries are based on watersheds. Together, the Regional Water Boards have about 875 staff members in 12 regional locations. Each Regional Water Board makes critical water quality decisions for its region. These decisions include setting standards, issuing waste discharge

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2 This section was prepared by State and Regional Board staff.

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requirements, determining compliance with those requirements, and taking appropriate enforcement actions.

The State Board's role in protecting water quality includes setting statewide policy, coordinating and supporting the Regional Water Board efforts, and reviewing petitions contesting Regional Water Board actions. The State Water Board is also solely responsible for allocating surface water rights. Today, the State Water Board, with roughly 600 staff members, is organized into four divisions that address water quality, water rights, financial assistance, and administrative functions. These functions not only support the State Water Board, but also the nine Regional Water Boards. Five full-time board members, appointed by the governor, are responsible for setting statewide water policy.

The boards completed a strategic plan in 1995 and revised it in 1997 and again in 2001. The 2001 Strategic Plan updates the mission, vision, values, operating principles, goals, objectives, performance measures and key strategic projects of the California Water Boards. The Water Boards' overall mission is to preserve, enhance and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations. The strategic plan highlights critical water resource issues to be addressed over the next five years, while considering our progress to date.

Since the passage of the federal Clean Water Act in 1972, California has made great strides in cleaning up its rivers, lakes, groundwater aquifers, and coastal waters. The primary focus of that effort, both in California and nationally, has been on wastewater discharged from "point sources" – sewer outfalls and other easily identifiable sources such as pipes. Much of that progress resulted from a regulatory effort that required a permit for each distinct point of discharge, combined with a sizable loan and grant program to help fund the facilities needed to clean up discharges to permit levels.

Despite this progress, significant challenges remain. For example, the permitting of point sources is becoming more complex and contentious as new state and federal mandates affect standards and enforcement. The 1999 Compliance Assurance and Enforcement Initiative established the goal of achieving measurable and continuing increases in compliance rates and identified a wide variety of challenges and proposed solutions. Improved data management is essential for improved compliance assurance and enforcement. Regulators, policymakers, and the public need better access to violation and enforcement information.

An even greater challenge is pollution resulting from "nonpoint sources" – runoff from urban areas, agriculture, timber operations, mine drainage and other sources for which there is no single point of discharge. Nonpoint source (NPS) pollution is the most significant California water quality challenge today, and requires flexible and creative responses. The challenge of NPS pollution lies in its very nature: diffuse, sporadic and difficult to trace to its sources, and thus more difficult to regulate through a permitting process. Because treatment to remove NPS pollutants is an expensive and potentially endless task, it is essential to keep these pollutants from reaching the water. Effective water quality protection requires a comprehensive approach to managing nonpoint sources. Prevention needs to be emphasized, and the cumulative effects of NPS pollution on entire watersheds must be considered.

More than 20 state agencies, in addition to the California Water Boards, have authorities, programs, or responsibilities relating to the control of NPS pollution. Coordinating and focusing such a large number
of entities to produce an effective NPS program in a state as large and geomorphologically diverse as California poses unique and difficult challenges. A NPS program plan, developed in coordination with the California Coastal Commission and other responsible State agencies, was approved in 2000. The NPS program plan includes a program strategy, implementation plan, and management measures to control NPS pollution. A NPS Implementation and Enforcement Policy, adopted in 2004, explains how the NPS program plan will be implemented and enforced. In addition, the California Water Boards have implemented a broad program of outreach, education, technical assistance and financial incentives. This program is supplemented by collaborative efforts with other agencies and non-governmental organizations. The goal is to provide an integrated statewide approach to controlling NPS pollution.

Total Maximum Daily Loads (TMDLs) is a tool used by the California Water Boards to address both point source and nonpoint source pollution. Federal law requires states to identify all water bodies that do not meet water quality standards. For those "impaired" water bodies failing to meet standards, the states must establish TMDLs. TMDLs define how much of a specific pollutant a water body can tolerate and still meet relevant water quality standards. The establishment of TMDLs in California is one of the most significant and controversial efforts undertaken by the California Water Boards. Not only do the TMDLs have to be established, but they must also be implemented by allocating responsibility for corrective measures among a variety of dischargers.

The 2002 303(d) list identifies 1,883 water body-pollutant combinations requiring TMDL development. The California Water Boards have developed guidance for this new and complex program, and are working with stakeholders to adopt and implement TMDLs. Many TMDLs are already well under way. In the long-term, additional resources will be required to accurately monitor and assess water bodies and subsequently determine the success of the TMDLs in restoring the state’s water to meet relevant standards.

Adequate and accurate monitoring and assessment is the cornerstone to preserving, enhancing, and restoring water quality. The information gathered from these monitoring activities is critical for: determining the effects of point and nonpoint source pollution; protection of drinking water supplies; conducting federal Clean Water Act assessments; determining trends in water and habitat quality; and developing water quality standards and then determining if they are being met. In November 2000, in response to Assembly Bill (AB) 982, the State Board submitted to the Legislature a comprehensive plan for the Surface Water Ambient Monitoring Program (SWAMP) and Groundwater Ambient Monitoring and Assessment (GAMA). The California Water Boards are now implementing these programs to the extent funding is available.

Finally, it is essential to recognize that pollution occurs without respect to jurisdictional or organizational boundaries and it is vital to create strategies to address cross-media-cross-organizational issues. After years of focusing on single point source pollution control, the California Water Boards are now looking at the bigger picture when developing methods of dealing with water pollution.

A key component of the strategic plan is to use a watershed management approach for water resources protection. To protect water resources within a watershed context, a mix of point and nonpoint source discharges, ground and surface water interactions, and water quality and water quantity relationships must be considered. These complex relationships present considerable challenges to water resource protection programs. The California Water Boards are responding to these challenges within the context of the
organization's Watershed Management Initiative (WMI). The WMI was developed to help the California Water Boards in meeting the goal of providing water resource protection, enhancement, and restoration while balancing economic and environmental impacts. The WMI provides a framework that overlies numerous separate and competing program priorities established by federal and state mandates.

The California Water Boards have been implementing the WMI since 1997 to better coordinate and focus limited public and private resources to address both point and nonpoint source water quality problems, especially in high priority targeted watersheds. By looking at entire watersheds rather than focusing on specific pollutants or polluters, the California Water Boards can develop unique solutions that consider all local conditions and pollution sources for each watershed. These solutions rely on the input and involvement of local stakeholders.

The Regional Water Boards have developed WMI Chapters that describe the Regional Water Board strategies for addressing water quality concerns on a watershed basis. These strategies rely on close coordination with other state, federal and local agencies in using limited fiscal and technical resources. The WMI Chapters identify priorities, describe the Regional Board watersheds and watershed-related activities, as well as program activities. Even though the chapters are meant to be long-term strategies, priorities can change quickly. Hence, the WMI Chapters are meant to be living documents so that relevant sections can be updated when new information on changing priorities is received. The WMI Chapters identify priority tasks and projects to be funded by existing resources, as well as those that are currently unfunded, including potential projects for grant applications. The California Water Boards can use the chapters in making informed decisions on which activities will be funded by specific workplans. The WMI Chapters are dynamic and represent the best information and strategies at the time they are written.

Statewide Concerns for Water Quality
(excerpted from Chapters 2 “California Water Today” and 3 “Planning for an Uncertain Future”, Volume 1)

California faces water quality challenges at the statewide, regional, and local levels. Significant statewide water quality issues are summarized here, while a discussion of specific regional and local challenges follows.

Water Supply and Water Quality

Water supply and use are inherently linked to water quality. Various water management actions such as transfers, water use efficiency, water recycling, conjunctive use of aquifers, storage and conveyance, Delta operations, land fallowing, and hydroelectric power potentially have water quality impacts. Alternatively, degraded water quality can limit, or make very expensive, some water supply uses or options because the water must be pretreated. Furthermore, water managers increasingly recognize that the water quality of various water supplies needs to be matched with its eventual use and potential treatment.

Contamination of Surface Water and Groundwater

Nonpoint-source pollution, including urban and agricultural runoff, is the largest contributor of human-induced contamination of surface water and groundwater in the state. Regarding surface water, about 13
percent of the total miles of California’s rivers and streams and about 15 percent of its lake acreage are listed as impaired. With respect to groundwater, samples analyzed from all 10 hydrologic regions showed that between 5 and 42 percent of public water supply wells exceeded one or more drinking water standards, depending on the region. Exceedances were usually for inorganic chemicals or radioactivity and, in particular, nitrate, which presents a known health risk. Largely agricultural or industrial regions had high percentage of exceedances for pesticides and volatile organic chemicals, respectively. Seawater intrusion in the Delta and in coastal aquifers, agricultural drainage, and imported Colorado River water can increase salinity in all types of water supplies, adversely affecting many beneficial uses.

Since December 31, 2002, discharges for irrigated agriculture and timber harvesting must be monitored, placing much uncertainty over the future of runoff from these activities. Along with urban runoff, the USEPA has identified agricultural runoff as the most serious threat to water quality in the country. Municipal and industrial wastewater and even some urban runoff are already formally managed. However, agricultural runoff, application of biosolids to farms, and agricultural drainage, especially in the Central Valley, will remain significant and potentially expensive challenges, with no obvious or simple solutions.

**Population Growth**

More population growth means more domestic wastewater discharges and urban runoff, which may in turn contaminate natural water bodies used as drinking water sources. Combined with demographic change, population growth can result in wastewater discharges that pollute California’s waters with emerging contaminants such as endocrine disrupters as well as higher concentrations of traditional contaminants.

**Emerging Contaminants**

The nature and impact of contaminants themselves may be changing in the future. Future population growth and demographic changes may further impair the quality of water bodies with both known and emerging contaminants, increasing the risk of drinking water. Demographic change may create larger groups of people, including the very old and the very young, which are vulnerable to risks from drinking water contaminants. While most of water contaminants are unregulated, that does not mean that they do not present a threat. Information on pollutant sources and their impacts is insufficient to adequately respond to existing problems. As new health risk information is obtained, water quality standards may need to become more stringent to protect health and safety. Re-evaluation of health effects research often leads to re-regulation of known contaminants. Moreover, there is a growing demand from consumers, expressed in opinion surveys as well as in the marketplace, for higher quality water.

**Legacy Contaminants**

In rural areas, the main pollution sources can come directly from land use practices, both present and past. As an example, the Sierra Nevada Ecosystem Project notes the adverse impact that hydraulic mining, which ceased during the 19th century, is still having on numerous Central Valley rivers. In addition, logging and related road cuts are a major cause of high sediment loads to North Coast streams. Roads result in significant erosion into watersheds throughout the coastal and inland areas. Grazing impacts, such as increased erosion, loss of streamside vegetation, loss of groundwater recharge ability in mountain meadows, and nutrient inputs, have contributed to the overall water quality degradation. Other legacies of
California’s economy and lifestyles include mercury, nitrate, PCBs, MTBE and other fuel components, perchlorate, and a variety of industrial and agricultural chemicals.

**People Without Clean and Safe Drinking Water**

Census figures from 1990 indicate that in California, the sixth largest economy in the world, almost 32,000 housing units obtained water from shallow wells and another 49,000 housing units obtained their water from some source other than dug wells, drilled wells, or public or private water systems. The Census counted about 68,000 housing units (less than 1 percent of the state’s population) that disposed their sewage by means other than a public sewer, septic tank, or cesspool.

Californians lacking access to safe drinking water are vulnerable to a higher incidence of disease than the general population. Untreated water can contain bacterial, parasitic, and viral contaminants. People at risk most often get their water from untreated surface water such as rivers, lakes, or springs. They may also have shallow unsealed wells or use irrigation ditch water. Surface water and shallow wells can become contaminated from rain runoff or flooding. A further concern is sewage disposal. Many rural communities have problems associated with failing septic drainfields and sewage surging in yards. This lack of wastewater infrastructure may contaminate potable water and domestic water sources.

**Environmental Justice**

Californians from disadvantaged and under-represented communities continue to face economic and environmental inequities with respect to water supply, participation in water policy and management decisions, and access to State funding for water projects. All Californians do not have equal opportunity or equal access to State planning processes, programs, and funding for water allocation, improving water quality, and determining how to mitigate potential adverse impacts to communities associated with proposed water programs and projects.

**Groundwater Overdraft**

Overdraft is the condition of a groundwater basin in which the amount of water withdrawn by pumping over the long term exceeds the amount of water that recharges the basin. Overdraft is characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years. Overdraft can lead to increased extraction costs, land subsidence, water quality degradation, and environmental impacts. A comprehensive assessment of overdraft in California’s groundwater basins has not been conducted since 1980 (DWR 1980), but it is estimated that overdraft is between 1 million and 2 million acre-feet annually (DWR 2003).

**Deferred Maintenance and Aging Infrastructure**

Some facilities of the SWP and the federal CVP have surpassed their design life and require significant rehabilitation or replacement. In recent years infrastructure failures have disrupted water deliveries. Current infrastructure disrepair, outages, and failures and the degradation of local water delivery systems are in part the result of years of underinvestment in preventive maintenance, repair, and rehabilitation. The California Performance Review (2004) cited a report by the Public Policy Institute of California estimating the state’s “water supply and wastewater treatment systems maintenance backlog” to be about $40 billion. (Dowall and Whittington 2003).
Global Climate Change

California’s water systems have been designed and operated based on data from a relatively short hydrologic record. Mounting scientific evidence suggests that forecasted climate changes could significantly change California’s precipitation pattern and amount from that shown by the record. Less snowpack would mean less natural water storage. More variability in rainfall, wetter at times and drier at times, would place more stress on the reliability of existing flood management and water systems.

Different precipitation and runoff patterns resulting from climate change could have impacts on water quality as well. For instance, seasonal increases in water volumes could dilute the concentrations of existing contaminants, while increased flows erode and wash more non-point source pollution into water bodies. Moreover, some water quality research suggests that water borne disease outbreaks may be associated with high runoff events. Individual water quality parameters such as turbidity, temperature, and toxicity could also be affected by the hydrologic impacts of climate change.

Regional Water Quality
(excerpted from Volume 3)

In preparing these regional water quality profiles, DWR relied upon the following documents from the California Water Boards, primarily in an effort to conform to the intent of Porter-Cologne (i.e. that regional basin plans are a part of the California Water Plan).

- Water Quality Control Plan, Regional Water Quality Control Boards
- Watershed Management Initiative Chapter, Regional Water Quality Control Boards
- 2002 California 305(b) Report on Water Quality, State Water Resources Control Board
- Strategic Plan, State Water Resources Control Board, Regional Water Quality Control Boards, November 15, 2001

In addition, the department also extensively used DWR’s Bulletin 118, California’s Groundwater, Update 2003 to prepare these reports.

North Coast

The North Coast Region generally has the most abundant water resources of any region of the state. The high volumes of precipitation and natural river runoff are a key component for most of the beneficial uses of its water bodies, including commercial and recreational fishing, shellfish harvesting, urban and agricultural use, and recreation. Many of the region’s forests and watersheds support threatened and endangered species of plants and animals, and the major rivers and streams contain significant anadromous fishery resources. This region also features important coastal resources, including Bodega Harbor and Humboldt Bay, as well as many small estuaries.

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3 DWR appreciates the contributions to and review of these regional water quality profiles by California Water Board staff. The author also wishes to acknowledge the input of the DWR District Office staff to these reports as well. Last, the staff of the California Bay-Delta Authority contributed to the Sacramento Valley, San Francisco Bay, and South Coast narratives; in particular, Authority staff primarily wrote the Sacramento-San Joaquin Delta section.
The region nonetheless is confronted by many water quality and water supply challenges. The North Coast Water Board’s water quality priorities highlight the need for control of nonpoint source runoff from logging, rural roads, agriculture (including grazing), and urban areas. In fact, sediment, temperature, and nutrients are the primary focus of the North Coast Water Board’s 303(d) list of impaired water bodies. Along the coast, nonpoint source pollution can cause microbial contamination of shellfish (and in particular, oyster) growing areas. Much of the region is characterized generally by rugged, steep, forested lands, with highly erodible, loosely consolidated soils; taken together with wildfires, extensive timber harvesting, and heavy precipitation primarily in the form of rainfall, the watershed is highly susceptible to erosion and landslides. Such heavy runoff in turn causes stream sedimentation that impacts habitat for spawning and rearing of anadromous fish. Channel modifications and water diversions have radically changed water quality conditions in many water bodies in the region, reducing natural flows that dilute contaminant concentrations and lessen their impacts. In the southern portion of this region, the development of new hillside vineyards is an increasing source of erosion, as well as pesticides.

The cold water fisheries in the region has been adversely affected by a number of water quality factors. The Eel, Mad, Mattole, Trinity, and Russian Rivers, as well as many other streams, are listed on the Clean Water Act 303(d) list as impacted by excessive sedimentation. One of the largest impacts from sediment is caused when salmonid spawning gravels are smothered. Timber harvesting can also decrease the canopy shading rivers and streams, thereby increasing water temperatures to levels that are harmful to cold water fisheries. The North Coast Region’s basin plan sets turbidity restrictions to control erosion impacts from logging and related activities, such as road building. The basin plan also specifically establishes temperature objectives for the Trinity River, in which reduced flows have disrupted temperature and physical cues for anadromous fish runs. Because of water diversions, summer temperatures in the Trinity as well as the Klamath can be lethal to salmonids. Fisheries can be further adversely affected by the lack of woody debris for pool habitat and sediment metering. The North Coast region is in the process of considering revisions to the basin plan temperature objectives and sediment prohibitions to address these issues.

The North Coast Water Board’s basin plan requires tertiary treatment of wastewater discharges to the Russian River, a major source of domestic water, and establishes limits on bacteriological contamination of shellfish growing areas along the coast. The plan also prohibits or strictly limits waste discharges to the Klamath, Trinity, Smith, Mad, and Eel rivers, as well as estuaries and other coastal waters. Nonpoint source runoff, especially after heavy precipitation, has resulted in contamination and closure of shellfish harvesting beds in Humboldt Bay. In the lower Russian River watershed stormwater runoff may also be contributing to high ammonia and low dissolved oxygen levels in Laguna de Santa Rosa, which is threatening aquatic life. Mercury in fish tissue is a water quality concern in Lakes Pillsbury, Mendocino, and Sonoma; a health advisory for mercury has been issued for Lake Pillsbury.

Groundwater quality problems in the North Coast region include contamination from seawater intrusion and nitrates in shallow coastal groundwater aquifers; high total dissolved solids (TDS) and alkalinity in groundwater associated with the lake sediments of the Modoc Plateau basins; and iron, boron, and manganese in the inland groundwater basins of Mendocino and Sonoma counties. Septic tank failures in western Sonoma County, at Monte Rio and Camp Meeker, and along the Trinity below Lewiston Dam, are a concern due to potential impacts to groundwater wells and recreational water quality.
Abandoned mines, forest herbicide application and historical discharge of wood treatment chemicals at lumber mills, including the Sierra Pacific Industries site near Arcata and Trinity River Lumber Company in Weaverville, are also regional issues of concern. Of note, according to the 305(b) report, only the Russian River basin has a long-term water quality data set in this region, which is necessary to evaluate quality changes over time. Current SWAMP sampling will contribute to this data set.

The drinking water for many of the communities on the North Coast, such as Klamath, Smith River, Crescent City, and most of the Humboldt Bay area, is supplied by Ranney collectors (horizontal wells adjacent to or under the bed of a stream). Erosion is undercutting some of these collectors, such as those in the Mad River supplying the Humboldt Bay Municipal Water District (which serves Eureka, Arcata, and McKinleyville). As such, these “wells” may actually be under the direct influence of surface water, which would require their filtration. The Russian River provides domestic water, in part with flows diverted from the Eel, to over a half million people, stretching from the cities of Santa Rosa and Ukiah, to southern Sonoma County and portions of Marin County. The city of Willits has had chronic problems in the past with turbidity, and taste and odor with water from Morris Reservoir, and high arsenic, iron, and manganese levels in its well supply. Organic chemical contamination has closed municipal wells in the cities of Sebastopol and Santa Rosa.

Central Coast

Unique coastal resources, such as Morro Bay and Monterey Bay, as well as the Salinas Valley, are the focus of water quality issues in this region. Sedimentation poses the greatest water quality threat to Morro Bay, one of 28 estuaries in the National Estuary Program. The Bay is also contaminated by pathogens (from agriculture, boats, and urban runoff), nutrients (due to fertilizers, animal wastes, and urban runoff), and heavy metals contaminating sediments (from abandoned mines in the upper watershed, as well as boat yards offshore). Elevated levels of bacteria have closed many of the shellfish growing beds in Morro Bay, and also have occasionally closed beaches in Santa Cruz County and southern Santa Barbara County. To protect special areas of biological significance, waste discharges are prohibited or limited in portions of Monterey Bay, a National Marine Sanctuary, and other specific coastal and ocean waters of the region. In its triennial review, the Central Coast Water Board also identified the need to incorporate new microbiological standards for water contact recreation.

The Salinas River watershed has significant nitrate contamination related to agriculture, the valley’s main land use. Groundwater overdraft is also a problem in the area, and seawater has now intruded six miles inland into the shallow groundwater aquifer around Castroville. The nearby Pajaro River watershed faces a variety of water quality threats, such as erosion (primarily from agricultural practices), urban runoff, sand and gravel mining, flood control projects, off-road vehicles, and historical mercury mining in the Hernandez Lake area. Coastal wetlands in Elkhorn Slough, a tributary to Monterey Bay located between the Salinas and Pajaro Rivers, suffers from erosion from strawberry and other cropped lands in its watershed. Elevated bacterial levels in the slough may be associated with a large dairy and waste operation in the watershed as well as septic tank systems. In addition, over 600 year-round vessels use the Moss Landing Harbor, and increasing the waste load to the slough. The accumulated effects of these water quality problems, along with the re-suspension of pesticides in sediments, have restricted shellfish growing in Elkhorn Slough.

Beyond the Salinas Valley, other regional water quality concerns include one of the nation’s worst oil spills at Unocal’s Guadalupe Oil Field in the Santa Maria River watershed. Nutrients and pathogens
impact the San Lorenzo River basin, from septic systems, horse corrals, and urban runoff, as well as erosion from logging, urban development, and road maintenance. Groundwater basins that are impacted by salinity include the Hollister, the Carrizo Plain, the Santa Maria and Cuyama Valleys, San Antonio Creek Valley, portions of the Santa Ynez Valley, and Goleta and Santa Barbara.

**Sacramento Valley**

Surface water quality in the watershed is generally good, making the Sacramento River one of the most desirable water sources in the state. Nonetheless, turbidity, rice pesticides, and organophosphate pesticides such as diazinon can affect fisheries and drinking water supplies. For instance, the decline of fisheries in the Sacramento River is in part related to water quality problems on the river’s main stem: unsuitable water temperature, toxic heavy metals (such as mercury, copper, zinc, and cadmium) from acid mine drainage, pesticides and fertilizer in agricultural runoff, and degraded spawning gravels. Holding of rice field drainage, allowing for degradation or rice herbicides, has effectively addressed this water quality concern among downstream water users, in particular, the city of Sacramento. In the Cache Creek watershed, Clear Lake suffers from large mercury, sediment, and nutrient loadings, the latter leading to nuisance algae blooms. Along with a few select other water bodies, the basin plan specifically prohibits direct discharges of wastes into Folsom Lake and the Lower American River downstream to its confluence with the Sacramento; waste discharges from houseboats on Shasta, Clear Lake, and in the Delta are also banned. High density recreation use of Whiskeytown and Shasta reservoirs may be contributing to their high bacteria levels.

In its triennial review, the Central Valley Water Board identified mercury loads, a legacy of California’s gold mining heritage, as one of the most significant water quality problems in the region. In particular, the Cache Creek watershed is the major source of mercury to the Delta; to a lesser extent, mercury is also a concern in Lake Berryessa and Marsh Creek Reservoir. An organic form of mercury, methylmercury, is a neurotoxin that is especially dangerous to fetuses and infants, attacking the central nervous system and causing an array of developmental and other problems. Because of methylmercury’s bioaccumulative properties, several water bodies in the Sacramento region have fish consumption advisories. In addition, the Central Valley Water Board has amended its basin plan to include a control program for mercury in Clear Lake and will be considering further amendments to address mercury in Cache Creek and its tributaries and the Delta waterways. Pesticide management and agricultural water discharges have recently received new attention due to the legislative requirement that the Regional Water Boards review their waivers associated with these activities. Coalitions within the region are forming partnerships to address this issue through a watershed approach as provided for by the Central Valley Water Board and affirmed by the State Water Board in their review of the Irrigated Lands Conditional Waiver. Stakeholders within the region are working to find a solution that encompasses the protection of beneficial uses, meets current and future water quality regulations, and allows for a sustainable agricultural economy.

Groundwater quality in the Sacramento River Region is excellent, though there are local groundwater problems. Naturally occurring salinity impairs wells at the north end of the Sacramento Valley. Groundwater in the vicinity of the Sutter Buttes is impaired due to the local volcanic geology, and hydrogen sulfide is a problem in wells in the geothermal areas in the western part of the region. Human-induced impairments, like nitrate, are generally associated with agriculture and septic tanks; the latter is especially an issue in Butte County, where 150,000 of its 200,000 residents rely upon individual septic systems. Septic tanks are often inappropriately sited in shallow, unconfined or fractured hard rock
aquifers, where insufficient soil depth is available for necessary leaching. Heavy metals from historic burn dumps also contaminate groundwater locally. In the Sierra foothills there is potential for encountering uranium and radon-bearing rock or sulfide mineral deposits containing heavy metals. Perchlorate, used as an oxidizer or booster for solid rocket fuel and now a human health concern in domestic water, has contaminated wells in the Rancho Cordova region near Sacramento.

**San Joaquin River**

The major water quality problems of San Joaquin River basin are a result of depleted freshwater flows, municipal and industrial wastewater discharges, salt loads in agricultural drainage and runoff, and other pollutants associated with agricultural irrigation and production, including nutrients, selenium, boron, organophosphate pesticides (such as diazinon and chlorpyrifos), and toxicity of unknown origin. The Central Valley--which covers San Joaquin River, as well as the Sacramento River and Tulare Lake basins--has 40 water bodies impaired due to agriculture, including 800 miles of waterways, and 40,000 acres in the Delta. In its most recent triennial review of its basin plan, the Central Valley Water Board identified as high priorities salinity and boron discharges to the San Joaquin River, low dissolved oxygen problems in the lower San Joaquin, organophosphorous pesticide control generally, and a policy for protecting Delta drinking water quality.

High salinity is a problem in the San Joaquin basin, because of the greatly altered flow regime of the River; most of the San Joaquin is diverted from its natural course at Friant Dam. Moreover, irrigation water from State and federal projects annually import over a half million tons of salt to the Westside of the San Joaquin River basin. Water released from New Melones Reservoir on the Stanislaus River is currently used to help meet the salinity and dissolved oxygen requirements at Vernalis on the San Joaquin. Agricultural drainage and discharges from managed wetlands are already formally managed under permit in the 370,000-acre Grasslands watershed, which contributes high levels of salts, selenium, boron, and nutrients to Mud and Salt Sloughs, which in turn are the primary contributors of selenium to the San Joaquin River. Dairies, stockyards, and poultry ranches are also a concern in the region for their loadings of pathogens, nutrients, salts, and emerging contaminants (such as antibiotics) to water bodies. Some dairies and other agricultural operations are already subject to regulatory review. Water releases from managed wetlands, part of State and federal wildlife refuge system, also discharge salts and nutrients. Erosion of Westside streams is the primary source of organochlorine pesticides in the San Joaquin River.

Migrating and spawning salmonids can face high temperatures in the Stanislaus, Tuolumne, and Merced rivers downstream from dams during certain times of the years, depending upon hydrologic and water supply conditions. Contamination of fish are also a concern in these three rivers as well as the main stem of the San Joaquin River. For example, the Central Valley Regional Water Quality Control Board cites one study of the 43-mile reach of the San Joaquin, between its confluences with the Merced and the Stanislaus, to be toxic to fish about half the time. In the Lower San Joaquin River, low dissolved oxygen, or DO, in the Stockton Deepwater Ship Channel is attributable to warm temperatures, low flows, nutrients, and channel configuration; this low DO area is potentially a barrier to fall run Chinook salmon migrating to the Merced, Tuolumne, and Stanislaus rivers to spawn. The Central Valley Water Board is considering a basin plan amendment to improve the dissolved oxygen conditions at this location.

Groundwater quality throughout the region is generally suitable for most urban and agricultural uses. There are, though, some 1,000 square miles of groundwater contaminated with salinity, mostly along the
western edge of the Valley floor, where the high-saline marine sediments of the Coast Range exist. The salinity of groundwater in the region increases when the evapotranspiration of crops and wetlands leaves behind the majority of the salt contained in the imported water. In addition, high water table conditions underlying marginal lands along the Westside of the San Joaquin River Basin contribute to subsurface drainage problems. In order to maintain a salt balance in the root zone, much of this salt is leached into the groundwater. For aesthetic purposes (i.e. taste), DHS regulations recommend that drinking water contain less than 500 mg/L of salinity as measured by total dissolved solids (TDS); for agricultural uses, water with a salinity of less than 450 mg/L TDS is generally acceptable. While the DHS recommendation is adopted by reference into the basin plan to protect domestic use of groundwater, the basin plan contains no numerical salinity objectives for protection of agricultural beneficial uses.

Nitrates, from the disposal of human and animal waste products or the inefficient application of fertilizer or irrigation water, have contaminated 200 square miles of groundwater, presenting a threat to domestic water supplies. Pesticides have contaminated 500 square miles of groundwater, primarily in agricultural areas on the east side of the San Joaquin Valley, where soil permeability is higher and depth to groundwater shallower. The entire Central Valley is home to approximately 500,000 household septic systems, which are more susceptible to failure than community wastewater systems, and can contaminate groundwater with nitrates and microbes. The most notable agricultural contaminant detected in groundwater samples from the region is dibromochloropropane (DBCP), a now-banned nematicide, found mostly along the State Route 99 corridor. There are 200 square miles of groundwater contaminated by naturally occurring selenium.

As of January 1, 2003, SB 390 ended previous conditional waivers of waste discharge requirements (WDRs) for 23 types of waste discharges, including irrigated agriculture and logging. Previously, a petition from three environmental groups requested the rescinding of these waivers, because of concerns about pesticides in discharges. Unlike the federal Clean Water Act—which specifically exempts agricultural discharges from regulation—the State’s Porter-Cologne Water Quality Control Act allows a waiver from regulation only if it is not against the public interest. The Central Valley Water Board granted such a waiver to irrigated lands in 1982, exempting their discharges from WDRs. That waiver did have conditions, but because of a lack of staff resources, the Central Valley Water Board did not review compliance with them. SB 390 allows for the continuation of waivers, but only if specifically renewed by the Regional Water Board, subject to a five-year review.

Relative to other regions, discharges from irrigated lands—which include managed wetlands and nurseries—have their greatest impact in the Central Valley, which covers 40 percent of California’s land area, and contains seven million irrigated acres and at least 25,000 individual agricultural dischargers. As an interim measure, the Central Valley Water Board adopted in July 2003 a pair of conditional waivers for such discharges to surface water, one for “coalition groups” and the other for individuals, covering surface runoff (tailwater), “operational spills” (excess water diverted but not used), subsurface drainage (to lower the water table for growing), and stormwater runoff. Commodity-specific and low-threat waivers and general permits may also be possible. Waiver conditions this time include water quality monitoring and implementation of BMPs (or “management measures”) to control pollution. This new waiver program, which focuses on capacity building and data collection (including monitoring for toxicity and drinking water constituents of concern), expires on December 31, 2005. Subsequently, a 10-year implementation program is envisioned to fully protect the state’s waters for their beneficial uses from discharges from irrigated lands, in order to meet water quality objectives.
While agricultural land use currently impacts water quality, rapid urbanization of the Central Valley, converting undeveloped or agricultural lands to residential and commercial use, may present different or new water quality problems in the future. The Central Valley Water Board has recently begun requiring many municipal dischargers to implement costly tertiary treatment of wastewater.

**Mountain Counties**

By virtue of their location, domestic water users in the Mountain Counties generally benefit from higher quality water than most other Californians. Many water supplies are from pristine foothill or mountain sources, which are largely unaffected by agricultural or urban pollution. Unfortunately, all too often this higher quality water is degraded while in transit through the numerous open ditch delivery systems. Drainage from abandoned mines, including Penn Mine in the Mokelumne River watershed, contributes metals and other water quality problems downstream. Mercury was imported to the region as part of the gold mining process and remains as a legacy of that era. Erosion from natural flooding, logging and land development, and areas devastated from forest fires, introduces sedimentation and nutrients to waterways, as well as causing elevated temperatures due to the loss of riparian shade canopy. This is a concern to both domestic water treatment operations and migration and spawning of salmonids, particularly below the major dams on the Stanislaus, Tuolumne, and Merced Rivers. The conversion of agricultural land to residential use, and undeveloped land to both agricultural and residential use, could present different or new water quality impacts in the near future.

Many small water systems in the foothills and mountains of California have historically tapped surface water or springs with minimal or no treatment; other small systems rely upon water from open ditch systems, sometimes in use for over 100 years, used primarily for agriculture or hydropower and only incidentally for domestic water. However, with a greater recognition of the health risk posed by pathogens in drinking water sources, these systems must now maintain reliable filtration and disinfection facilities. In addition, low housing densities in this region result in a large number of isolated, small water systems, which individually do not have the technical or financial capacity to upgrade their treatment facilities and infrastructure, and cannot consolidate to take advantage of a larger rate base. When such treatment upgrades are infeasible, water purveyors are instead requiring customers receive bottled water. Also common to the ditch delivery systems within the Mountain Counties region is the tendency to have large conveyance losses and sanitary hazards. Repairs on some systems have been opposed by various groups and landowners who argue the loss of the aesthetics of the flowing canal, loss of vegetation and wildlife created by leakage and percolation and who see the water saved as growth inducing. Many other water users in this region are on private wells, which are unregulated and, thus, may never have been assessed for contamination.

The Mountain Counties areas are concerned with forest fires and the damage they cause to the watersheds and the wooden infrastructure associated with the ditch systems. Every year, numerous forest fires occur in the Sierra Nevada and expose the watershed to erosion and change runoff timing. Sediment can obstruct water flow in open ditches, reduce reservoir capacity, add nutrient loading, diminish water quality and cause excessive algae growth. Fires have damaged components to the ditch systems including diversion structures and flume sections. As a result communities have been left without water for extended periods of time.
Like surface water, groundwater in this region is generally of good quality, but it may be contaminated by naturally occurring radon, uranium, and sulfide mineral deposits containing heavy metals. In particular, radon contamination is associated with granite, such as the granite batholith of the Sierra Nevada. Meeting state secondary standards for both iron and magnesium can also be difficult. Also, because of the lack of community wastewater systems, individual septic tanks are prevalent in this region, potentially adversely affecting groundwater quality.

Sacramento-San Joaquin Delta

The Delta is a source of drinking water for over 23 million Californians, which underscores the importance of carefully managing a wide range of water quality issues in the region.

Water Standards

Requirements of the State Water Board govern release of upstream flows and curtailment of export pumping to maintain Delta water quality and outflow requirements for the San Francisco Bay. The first water quality standards for the Delta were adopted in May 1967, when the State Water Rights Board (predecessor to the State Water Board) released Water Right Decision 1275, approving water rights for the State Water Project while setting agricultural salinity standards as terms and conditions. These requirements were altered in 1971 under Decision 1379 (D-1379), which added standards the CVP and SWP are to meet for non-consumptive uses (water dedicated to fish and wildlife), along with agricultural, municipal, and industrial consumptive use standards. In 1978, the State Water Board issued D-1485 and the 1978 Delta Plan, which together revised flow and salinity standards and required the US Bureau of Reclamation (USBR) and Department of Water Resources (DWR) to reduce pumping, release stored water upstream, or both to meet the standards.

In 1986, Congress passed the CVP-SWP Coordinated Operation Agreement (Title I of PL 99-546), requiring that the CVP be operated in coordination with the SWP to meet state water quality standards. Also in 1986, the Supreme Court upheld the Racanelli Decision, which recognized State Water Board authority and discretion over water rights and water quality issues, including authority over CVP operations. As a result of increasing use of Delta waters combined with escalating environmental and fishery problems, the State Water Board adopted a new Bay-Delta Plan in 1991, which included objectives for salinity, dissolved oxygen, and temperature. The USEPA followed with federal standards for the Estuary through USEPA regulations in 1994. In December of 1999, the State Water Board issued a new Decision 1641 as a part of the 1995 Bay-Delta Water Quality Control Plan, which replaced earlier Delta standards and conditioned the water rights permits of the SWP and CVP to implement the new objectives. The requirements set in D-1641 covered Phases 1 – 7 of the Bay-Delta Water Rights Hearings. In April of 2001, the State Water Board went on to adopt Water Rights Order 2001-05, which facilitates negotiations to settle the responsibilities for implementing and maintaining the 1995 WQCP.

Currently the SWP and the CVP coordinate project operations to maintain the standards established by D-1641, by releasing water from upstream reservoirs for Delta outflow requirements, and by curtailing export pumping at the SWP Banks and CVP Tracy Pumping Plants during the specified time periods. This combination of Delta outflow requirements and export pumping limitations impose the most difficult

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4 This section was prepared primarily by the staff of the California Bay-Delta Authority.
challenges to the process of transporting water from upstream reservoirs to meet water needs in the San Joaquin Valley, San Francisco Bay Area, and Southern California.

**Salinity**

The impact of salinity on water quality in the Delta is important and directly related to water supply reliability. The balance of ocean tides, river outflows, salinity input from agricultural and urban drainage, export pumping rates, and other factors directly impacts aquatic health in the Delta and the public health of those who use Delta drinking water. South Delta agricultural diverters are often faced with high levels of salinity, which can damage crops and reduce productivity. DWR’s South Delta Temporary Barriers Project helps limit saltwater intrusion into areas of agricultural diversions, while also raising water levels.

**Mercury**

Mercury can be found throughout the Delta as a result of the mining activities that were widespread throughout the Central Valley, such that the entire Delta is presently on the State Water Board’s 303(d) list for sources of mercury. Miners extracted mercury in the Coastal Range, and then used the mercury to separate gold from rock in the Sierra. Abandoned gold and mercury mines continue to leach mercury today. While mercury in its natural form is usually not easily transmitted into living organisms, some natural processes encourage conversion to methyl mercury, a powerful neurotoxin harmful to animals and humans that accumulates in fish tissue. Restoration of wetlands have faced increasing scrutiny because the conversion of mercury to methylmercury (i.e. methylation) may be encouraged by certain natural wetland processes.

**Dissolved Oxygen (DO)**

Current water quality standards call for at least 5 milligrams per liter of dissolved oxygen to protect aquatic organisms (including fish), allow for successful fish reproduction and juvenile rearing, and prevent odor problems. Discharges into the San Joaquin River and the Delta sometimes contain material with a high biochemical oxygen demand or a high nutrient level, which can encourage algae growth and cause subsequent oxygen depletion. These discharges, along with depleted freshwater flows, channel configuration, and water temperatures, have resulted in isolated areas in the Delta with DO levels below the current standard. On the San Joaquin River and the Stockton Deep Water Channel (the dredged portion of the lower San Joaquin its mouth near Antioch upstream to the Port of Stockton), low DO levels may pose a barrier to fall-run salmon migrating upstream to spawn.

**Organic Carbon (TOC)**

Organic carbon is itself not a harmful constituent – in fact it’s essential for aquatic life. Problems occur when water of high organic carbon content is treated in drinking water treatment plants, which must use chemicals to inactivate harmful pathogens. Some forms of organic carbon react with some of these beneficial disinfection agents, such as chlorine, producing potentially carcinogenic disinfection byproducts (e.g. trihalomethanes). Since wetland restoration efforts could potentially increase the level of vegetation and organic carbon in Delta water supplies, there may be conflicting objectives between ecosystem and water quality initiatives, as is also the case with mercury. Because some organic carbon

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5 The Clean Water Act requires that states and territories identify impaired and threatened water bodies that are not expected to meet water quality standards, as outlined in Section 303(d) of the Act. Placement on these lists require the development of Total Maximum Daily Loads (TMDLs), which establish the maximum amount of pollutants the water body can receive while still meeting water quality standards.
processes are still poorly understood, much of the current work is focused on investigating how carbon is used in the aquatic food web and how natural and anthropogenic factors affect the type and amount of organic carbon released into the system.

**Selenium**

Selenium enters the Delta region from multiple sources, including natural groundwater discharges from selenium-containing soils, agricultural runoff, and refinery inputs from the San Francisco Bay. Selenium, like mercury, bioaccumulates in aquatic life and has been shown to have negative affects on fish and waterfowl. High selenium concentrations could cause disruptions in drinking water and agricultural water deliveries, and are often correlated with high salinity levels as well. Both the Central Valley and San Francisco Water Boards have developed TMDLs for the San Joaquin River and San Francisco Bay, respectively.

**Pesticides**

Pesticides are insecticides, herbicides, fungicides, and other substances used to prevent, destroy, repel, or prevent pests. In the Delta, several types of chemical pesticides are widespread, including organophosphates, organochlorines, and pyrethroids. Each of these materials has certain risks for humans and aquatic organisms because they are, by design, meant to disrupt biological processes.

Organophosphates (also called organophosphorous pesticides) affect the nervous system, and were used in World War II as nerve agents in addition to being used as insecticides (such as chlorpyrifos and diazinon). While usually not persistent in the environment, organophosphates have been found in the Bay-Delta watershed, and could impact the distribution and abundance of aquatic species. Organochlorines, which include DDT and chlordane, were used extensively in the past but now are much less widely used because of their toxicity and persistence. Like mercury, organochlorines bioaccumulate in fish, and could contaminate humans and animals who consume them. Pyrethroids are synthetic versions of a naturally occurring pesticide in chrysanthemums, and some forms can be extremely toxic to the nervous systems of fish and invertebrates. Pyrethroids are becoming more widely used, but current monitoring equipment is unable to measure concentrations in the environment. The Central Valley Water Board is developing TMDLs for the Delta and the San Joaquin River to address organophosphates.

**Toxicity of Unknown Origin**

Besides those constituents known to impact organisms in the Delta, there are likely other substances that have not yet been identified that are contributing to toxicity problems. There are also many other constituents and issues related to water quality that are important in the Delta region. Like some forms of organic carbon, bromide, which is a component of salinity, can produce disinfection byproducts when treated with certain, necessary disinfection processes used in domestic water treatment plants. Various pathogens are also present in Delta waterways.

**San Francisco Bay**

The San Francisco Bay Hydrologic Region is centered on the San Francisco Estuary and its water quality. The estuary’s immediate watershed is highly urbanized, resulting in contaminant loads from both point

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*6 Much of the pesticide information is taken from U.S. EPA Pesticide Program website (www.epa.gov/pesticides).*
and non-point sources, as well as pollutants from the Napa, Petaluma, and Guadalupe Rivers, the Sacramento San Joaquin Delta, and the Central Valley. Bay Area residents generally receive good quality drinking water that varies by source and treatment. Sources range from high quality Hetch Hetchy and Mokelumne River supplies, local surface and groundwater, and variable-quality Delta water. Utilities that depend on the Delta for all or part of their domestic water supplies do meet the current drinking water standards, though they remain concerned about issues such as microbial contamination, salinity, and organic carbon. [budget studies consistently show that costs to meet future water quality standards are relatively low]. Delta water constitutes about one-third of the domestic water in the Bay region.

The San Francisco Estuary is the main focus of water quality issues in this region. Water and sediment in the estuary meet quality guidelines for most contaminants, with constituents in water meeting toxicity and chemical guidelines about 87 percent of the time. Sediment concentrations, though, are more problematic, due to legacy pollutants, with only about 60 percent of the sediment samples meeting chemical guidelines and passing toxicity tests. Over time, estuary water quality has significantly improved, for instance, with fewer toxic episodes and decreased silver concentrations in the South Bay. Implementation of secondary treatment of domestic wastewater has dramatically improved the quality, especially the oxygen content, of the San Francisco Estuary, as has the reduction in the use of organophosphate pesticides. Currently major water quality issues include control of stormwater, urban, and construction site runoff, as well as runoff and discharges from the vast Central Valley and Delta watershed. Legacy pollutants, such as polychlorinated biphenyls (PCBs) and mercury, contaminate fish in the estuary. Other water quality concerns include copper and nickel in the South Bay, selenium from Contra Costa refineries, erosion from vineyards in Napa and Sonoma Valleys, pesticides in urban creeks generally, and toxicity of water and especially sediment. Habitat in the Suisun Marsh is threatened by increasing sedimentation. Exotic and invasive species, such as the Chinese mitten crab and Asian clam, threaten to undermine the estuary’s food web and alter its ecosystem. Because San Francisco Bay has several active seaports, discharge of ballast water and vessel wastes, and maintenance dredging and disposal of contaminated sediments, are water quality concerns. New contaminants are emerging that may be causing impacts to the aquatic ecosystem, including flame retardant PBDEs (polybrominated diphenyl ethers), pyrethroid insecticides, and compounds from pharmaceuticals and personal care products. Already verboten in many European countries, California will ban two types of PBDEs because of their impact to mothers and nursing babies, beginning in 2008.

The Bay acts as a sediment repository, so persistent, sediment-bound contaminants, such as mercury, dioxins, PCBs, and organochlorine pesticides have accumulated over time. These compounds also bioaccumulate in the food chain, causing contaminating Bay fish and endangering their consumers, including humans and wildlife. Happily, new inputs of the persistent sediment contaminants in the Estuary are controlled as the use of most organochlorine pesticides and PCBs are banned, and the concentrations in the sediments and in organisms appear to be declining. The San Francisco Water Board is developing new regulatory requirements to address the mercury sources to the Estuary, most significantly, the New Almaden mine, as well as the thousands of abandoned mercury and gold mine tailings in the Central Valley watershed. Mercury contamination in Estuary fish, such as the striped bass has remained high for more than 30 years. Wetland restoration could increase mercury methylation processes and cause higher contamination in fish.

Since 1993, the San Francisco Regional Monitoring Program has been providing monitoring and synthesis of findings on water, sediment and fish contamination issues in the bay. The annual conference
and publication “Pulse of the Estuary” is produced by the San Francisco Estuary Institute and summarizes the state of what is known about the Estuary’s water quality issues. Outside of the San Francisco Estuary, Tomales Bay is one of only four commercial shellfish growing areas on the entire west coast. Some of the coastal watersheds of Marin and San Mateo counties provide important habitat for listed species of coho salmon and steelhead. Sediment threatens water quality and habitat in Bolinas Lagoon, the only wetland on the West Coast designated as a Wetland of International Significance by USFWS.

The quality of domestic water supplies in the San Francisco Bay Region is generally excellent, but does vary due to source and treatment. For instance, the source water quality of San Francisco Public Utilities Commission’s Hetch Hetchy supply, East Bay Municipal Utility District’s Mokelumne River supply, and local surface and groundwater supplies is generally better than that of water diverted from the Sacramento – San Joaquin Delta. However, even with a high quality water source, San Francisco recently implemented chloramination disinfection of drinking water, in order to reduce disinfection byproducts. Alternatively, the storage of higher quality Delta water in Los Vaqueros Reservoir, as well as implementation of advanced water treatment, has significantly improved the water quality in the service area of the Contra Costa Water District.

Most utilities that deliver water from the Delta are pursuing a range of projects to protect and improve the quality of the water that they serve, including the ability to store Delta water when it is relatively good, watershed management, source blending, and advanced treatment. Examples include CALFED funded projects to relocate agricultural drains and line portions of the Contra Costa Canal that may be impacted by poor quality local groundwater. Utilities in Solano County use a blend of local surface water and Delta water of variable quality delivered via the North Bay Aqueduct. Santa Clara Valley Water District, Alameda County Water District, and Zone 7 Water Agency employ a diversified portfolio of water sources, including Delta water, Hetch Hetchy, local surface water, and groundwater. The Bay Area Water Quality and Supply Reliability project is evaluating a broad array of cooperative regional projects to benefit ACWD, Zone 7, SFPUC, BAWSCA (representing the 28 wholesale water customers of the SFPUC), CCWD, SCVWD, and EBMUD. Some of the regional project concepts being considered in this study include the expansion of storage in Calaveras and Los Vaqueros reservoirs, additional recycling, additional conservation beyond existing BMPs, and desalination.

In general, groundwater quality throughout most of the region is suitable for most urban and agricultural uses with only local impairments, such as leaking underground storage tanks. Groundwater in the Livermore Valley and Niles Cone (southern Alameda County) basins has high levels of total dissolved solids, chloride, boron, and hardness; both Zone 7 and ACWD are implementing wellhead demineralization projects to improve groundwater basin and delivered water quality. Meanwhile, parts of the basin underlying the Santa Clara Valley are threatened by pollutants from various industrial activities and historic agriculture. Elsewhere, groundwater in Petaluma Valley and the Gilroy-Hollister Valley has high levels of nitrate impacting domestic use of wells. Recharge projects and use of imported water has successfully stopped or reversed seawater intrusion into aquifers around the Bay.

More monitoring and studies are needed to determine the effects of contaminants, including the emerging contaminants, on the aquatic ecosystem of the bay. As the population continues to grow in the Bay Area, stormwater runoff, particularly from urban areas will need to continue to improve in order to reduce contaminant loads to the estuary. Stricter regulatory requirements are being developed to address the major Bay contaminants such as PCBs and mercury. However, even if all the sources of these
contaminants were abated, it would take a very long time before sediment contaminants were reduced by degradation, transport to the ocean or atmosphere, or burial under new sediment deposits. Continued monitoring is needed to evaluate the effectiveness of management actions, detect long-term trends and investigate emerging issues from new contaminants.

**Tulare Lake**

Salinity is the primary contaminant affecting water quality and habitat in the Tulare Lake Region, a consequence of agricultural operations compounded by groundwater overdraft. Agricultural runoff and drainage are also the main sources of nitrate, pesticides, and naturally occurring selenium that endanger groundwater and surface water beneficial uses. The basin also has a relatively large concentration of dairies that contribute microbes, salinity, and nutrients to both surface and groundwaters. Nitrate has contaminated over 400 square miles of groundwater in the Tulare Lake Basin. In addition, more than 800 oilfields discharge a wide variety of contaminants to the waters of the region.

On the region’s Westside, though, salinity, sulfate, boron, and selenium limit the uses of groundwater. Where groundwater quality is marginal to unusable for agriculture, farmers use good quality surface water to irrigate crops, or blend higher quality surface water with poor quality groundwater to create a larger supply. Irrigation with saline imported water, as well as the inefficiency of some crop irrigation systems, results in percolation of applied water into the shallow unconfined aquifers, causing drainage problems and degrading groundwater quality. This marginal to poor quality groundwater has reached crop root zones in this area and is threatening the viability of agriculture there.

Naturally occurring arsenic and man-made organic chemicals—pesticides and industrial chemicals—have contaminated groundwater used as domestic water supplies in this region. For example, the lone well that provides water for city of Alpaugh’s 760 residents—40 percent of which live in poverty—contains unsafe levels of naturally occurring arsenic. By 2006, new federal and State rules will force more than 50 central San Joaquin Valley communities, including Hanford, Pixley, and Tranquility, to cut arsenic levels to one-fifth the current allowable levels. The closing of 40 wells in Fresno due to high levels of dibromochloropropane (DBCP), trichloroethylene (TCE), and other organic compounds required the installation of activated charcoal filtration systems to remove these contaminants.

The quality of local surface water from the Kings River and the San Joaquin River (diverted south through the Friant-Kern Canal) is excellent for irrigation, and municipal and industrial uses. The Central Valley Water Board did, though, specifically identify salinity in the lower Kings River as a priority in its 2002 Triennial Review. On the Westside, DWR has sought solutions to the flooding on the Arroyo Pasajero, which threatens the California Aqueduct. The Aqueduct, which forms a barrier to Arroyo floodwaters and sediment flow, is at risk of failure during major rainstorms in the watershed. Further, the asbestos in the Arroyo sediment load that enters the aqueduct during floods has raised questions of possible health risks. Both Panoche and Silver Creeks contribute large sediment loads to the Aqueduct and the Valley floor; Panoche Creek also has elevated levels of selenium.

In addition, the drainage water is sometimes contaminated with naturally occurring, but elevated, levels of selenium, boron and other toxic trace elements that threaten the water quality, environment, and fish and wildlife. Water planners had originally envisioned a master surface water drain to remove this poor quality water, but that proposal was never implemented. The U.S. Bureau of Reclamation has an obligation to provide agricultural drainage service to CVP westside acreage. To convey this sometimes
contaminated drainwater more directly to the San Joaquin River and away from the sensitive San Luis National Wildlife Refuge Complex, a portion of the San Luis Drain was reopened in September 1996 as part of the Grassland Bypass Project. The San Luis Drain was modified to allow drainage through six miles of Mud Slough, a natural waterway that passes through the San Luis National Wildlife Refuge Complex and a section of the North Grassland Wildlife Area.

The monitoring of San Joaquin Valley agricultural drainage water began in 1959 as a cooperative agreement between the California Department of Water Resources and the University of California. In 1984 the San Joaquin Valley Drainage Program was established as a joint federal and State effort to investigate drainage and drainage-related problems and identify possible solutions. In September 1990 the San Joaquin Valley Drainage Program summarized its findings and presented a plan to manage drainage problems in a report entitled "A Management Plan For Agricultural Subsurface Drainage and Related Problems in the Westside San Joaquin Valley ". In December 1991, several federal and State agencies signed a memorandum of understanding, and released an implementation strategy entitled “The San Joaquin Valley Drainage Implementation Program.” The purpose of the 1991 MOU and its strategy document was to coordinate various programs in implementing the 1990 recommendations.

In 1997 an Activity Plan was initiated by the member agencies of the San Joaquin Valley Drainage Implementation Program and the University of California to review and evaluate the 1990 Plan and update its recommendations. Eventually, the San Joaquin Valley Drainage Authority which includes districts in the Grassland, Westlands, and Tulare subareas was formed to develop a long-term solution for drainage problems in the Valley, which could include out-of-valley disposal. Studies continue in pursuit of cost effective ways to dispose of the drainage water.

In 2002, the U.S. Bureau of Reclamation released the San Luis report, which declared that an “in-Valley” solution to the drainage problem on the Valley’s Westside should be implemented. The proposed alternative includes the following features: a drainwater collection system, regional drainwater reuse facilities, selenium treatment, reverse osmosis treatment for the Northerly Area, and evaporation ponds for salts disposal.

Also in 2002, the Westlands Water District, and the United States reached a settlement agreement regarding drainage that the U.S. was legally bound to provide to Westside farmers. As a result of this agreement, the number of acres requiring drainage service in the San Luis Unit will initially be reduced by retiring approximately 33,000 acres, part of a proposal to retire up to a total of 200,000 acres.

**North Lahontan**

Water quality in the North Lahontan region is generally excellent but many communities face specific water quality problems. These include groundwater contamination from septic tank discharges in urban subdivisions in the vicinity of Susanville and Eagle Lake, and MTBE contamination in South Lake Tahoe. Drinking water quality has also become a greater issue for many surface water systems around Lake Tahoe, forcing many of the smaller private systems to consolidate or change ownership because they are unable to afford the new monitoring and treatment regulatory requirements. South Tahoe Public Utility District, the largest water purveyor in the Tahoe basin, is also experiencing some difficulty in meeting these water quality requirements. The abandoned Leviathan Mine, a Superfund site in the upper reaches of the Carson River watershed, impacts local creeks with acid mine drainage water. The top water quality issues emerging from the Lahontan Water Board’s 2003 Triennial Review included proposals to
revise the waste discharge prohibition for piers in Lake Tahoe, and sodium standards for the Carson and Walker Rivers and their tributaries.

Lake Tahoe is the subject of its own chapter in the region’s basin plan, and receives many specific and extraordinary water quality protections. The Porter-Cologne Water Quality Control Act bans the discharge of domestic wastewater from California in the Lake Tahoe basin; the same ban is in effect in Nevada by executive order, resulting in the export of all domestic wastewater from the basin. Discharges of industrial wastewater, wastes from boats and marinas, food wastes, and solid waste are also prohibited in the Tahoe basin. Lake Tahoe’s clarity has declined as development has increased around the shoreline, increasing the sediment load and nutrients reaching the lake and its tributaries. In the late 1960s, the clarity of the lake—as measured by the depth to which a “Secchi disk” (a small white disk of specific size) is visible—was about 100 feet; but in recent years, the average Secchi disk visibility has been closer to 70 feet. Nutrients, such as nitrogen and phosphorous used in landscaping fertilizers, can enter the lake via storm water runoff, promoting growth of algae and thereby reducing clarity. Nitrogen pollution in the basin is primarily due to vehicles, while phosphorous is mostly derived from erosion and dust (phosphate-based detergents are banned).

Roads and road maintenance activities, including snow removal and de-icing, are the focus of new restrictions that are intended to reduce erosion and other water quality impacts into the streams that enter Lake Tahoe. The traditional use of salt for road de-icing had resulted in adverse impacts to the trees and plants which help prevent erosion and sediment from flowing into the lake. Forest fires, grazing, and logging also present a threat to the lake’s water clarity due to related and subsequent erosion into the stream systems. The use of agricultural pesticides in the Lake Tahoe basin is prohibited, and the Tahoe Regional Planning Agency has more recently banned the use of two-stroke engines in all boats on Lake Tahoe, to prevent contamination from gasoline components such as benzene and MTBE. Other restrictions on land development and soil disturbances are employed in the continuing efforts to maintain or improve the lake’s water quality, and programs that purchase and preserve sensitive lands are being implemented. Lake Tahoe is now extensively monitored by many federal, State and special purpose agencies, such as the UC Davis Tahoe Research Group, and the University of Nevada’s Desert Research Institute.

**South Lahontan**

The quality of limited surface water is excellent in the region, greatly influenced by snowmelt from the eastern Sierra Nevadas. At lower elevations, though, groundwater and surface water quality can be degraded, both naturally (from geothermal activity) and through human activities (e.g. recreation, grazing). Nutrients entering Crowley Reservoir, on Owens River south of Mono Lake, have contributed to low dissolved oxygen levels in reservoir releases that can adversely affect fish downstream. Water quality and quantity are inherently related in the Owens River watershed due to the large exports of surface and groundwater to the city of Los Angeles. Arsenic, a known human carcinogen, is a health concern in the basin, and therefore, in Los Angeles as well, especially with the impending lower drinking water standard. The vast majority of public water supply wells meet drinking water standards. When these standards are exceeded, it is most often for TDS, fluoride, or boron. Several domestic water supply wells in the Barstow area have been closed due to historical contamination from industrial and domestic wastewater. Three military installations in the southwestern part of the region are on the federal Superfund National Priorities List because of volatile organic compounds and other hazardous contaminants, and the infamous PG&E chromium groundwater contamination site in Hinkley is also in
this region. In its triennial review, the Lahontan Water Board identified the need for site-specific ammonia objectives for Paiute Ponds and Amargosa Creek in Los Angeles County. Also, monitoring and cleanup of chromium in groundwater and cleanup of sites contaminated by mining wastes continue to be needed in the region.

South Coast

Like many regions in the state, water quality and water supply challenges are intertwined. The South Coast region must manage for uncertainties caused by population and economic growth. Growth will not only affect demand, but it will add contamination challenges from increases in wastewater discharges and urban runoff, as well as increased demand for water-based recreation. Outside the region, environmental and water quality needs in the Delta, Colorado River, and Owens River/Mono Basin systems affect imported water supply reliability and quality. The region must also assess and plan for impacts of climate variations and global climate change, as well as the cost of replacing aging infrastructure.

Given the size of the region and the diverse sources of water supply, the challenges to the region’s water quality are varied. Surface water quality issues in the South Coast are dominated by stormwater and urban runoff, which contribute contaminants—including trash—to local creeks and rivers. These pollutant sources, as well as sanitary sewer overflows, overwatering, ocean outfalls, tidal input, and even wildlife, can degrade coastal water quality, closing beaches and increasing the health risks from swimming. These sources also specifically affect water quality in the major bays—Santa Monica, Newport, and San Diego—along the South Coast. Newport Bay, for instance, suffers from excess algae blooms (due to nutrients), toxicity to aquatic life, high bacterial counts, and sedimentation. Shipping can also influence water quality, especially at the U.S. Naval Port in San Diego Bay and the Long Beach and Los Angeles harbors, where there are toxic sediment hot spots. Harbors and marinas and recreational boating threaten water quality through ballast water discharges (which can introduce invasive species), petroleum and sewage discharges and spills, biocides from boat hulls, boat cleaning and fish wastes, trash, and reduced water circulation. The South Coast Wetlands Recovery Project works to restore wetland habitat and eradicate exotic species in many watersheds of the region. Several dedicated wildlife and ecological reserves are located along the South Coast as well.

Constructed wetland projects in Hemet/San Jacinto, San Diego Creek, and Prado Basin, remove large loads of nitrogen from wastewater and urban runoff. Salinity, nitrogen, and microbes are the major contaminants in the Santa Ana River, affecting downstream beneficial uses such as swimming and groundwater recharge for domestic use. Because of upstream irrigation diversions, flows in the middle and lower Santa Ana are composed mostly of reclaimed wastewater, creating a year-round flow that is high in salinity. The Santa Ana suffers as well from an invasive exotic species, the giant reed Arundo donax. Other non-native, invasive species of concern in this region include the marine alga Caulerpa taxifolia along the San Diego coast, and salt cedar (Tamarix sp.) in various streams and rivers; both, like Arundo donax, have the potential to wreak havoc with native ecosystems. Lake Elsinore, the largest natural freshwater lake in southern California, experiences nuisance algae blooms from excess nutrients, impairing its ecological and recreational beneficial uses. Local groups have implemented many wetland and river restoration projects to improve water quality, for example, at Bolsa Chica and in Ballona Creek, as well as along the Los Angeles and San Gabriel Rivers. The U.S. and Mexico jointly built the South Bay International Wastewater Treatment Plant to treat a portion of the sewage from Tijuana, which flows across the international boundary into the San Diego basin, fouling Imperial Beach and the ocean.
The Chino Basin hosts the highest concentration of dairy animals in the United States. In a 40-square-mile area, well over 300,000 animals are maintained on approximately 300 dairies. Because of a lack of sufficient land to dispose of manure, as well as flooding from expanding suburban development, dairy runoff contributes nitrate, salts, and microorganisms to groundwater as well as surface water. Since 1972, the Santa Ana Water Board has issued waste discharge requirements to the dairies in this basin; in addition, pilot projects for sewering dairies and treating dairy washwater have also been recently completed. From brackish aquifers such as the Chino Basin, water utilities can use desalters to recover groundwater, but only if they have access to the regional brine line (the Santa Ana River Interceptor). Groundwater quality in this basin is integrally related to the surface water quality downstream in the Santa Ana River, which in turn serves as a source for groundwater recharge in Orange County. Orange County Water District and, to the north, West Basin Municipal Water District, operate groundwater injection programs to form hydraulic barriers, to protect aquifers from seawater intrusion.

Public health, environmental and economic concerns about the TDS content of wastewater, and the presence in treated wastewater of pharmaceuticals, household products, and other emerging contaminants, have grown with the expansion of water recycling programs in the South Coast region. The high salinity of imported Colorado River water limits the number of times water can be reused before the salt content becomes too high and wastewater can only be discharged to the ocean. Increased use of recycled water and marginal quality groundwater supplies during droughts can result in water quality problems for some local supplies that endanger future water management projects. For instance, groundwater recharge potential may be restricted because the Regional Water Board has established TDS requirements for recharge water in some groundwater basins to protect existing basin water quality.

The average TDS concentration of MWD’s Colorado River Aqueduct (CRA) water is about 900 mg/L while the average TDS content of SWP supplies is about 300 mg/L. The of Los Angeles Aqueduct supply has a significantly lower TDS concentration, typically about 160 mg/L. TDS levels in local groundwater supplies in the region vary considerably, ranging from 200 mg/L (Cucamonga Basin near Upland) to more than 1,000 mg/L (Arlington Basin near Corona). Local water uses also contribute significantly to overall salinity levels. For example, municipal and industrial use of water adds between 250 and 500 mg/L of TDS to wastewater. Key sources of local salts include water softeners (typically contributing from 5 to 10 percent of the salt load) and industrial processes.

The long-term salt balance of the region’s groundwater basins is an increasingly critical management issue. Smaller basins like the Arlington and Mission groundwater basins were abandoned as municipal supplies because of high salinity levels. These basins have only recently been restored through brackish water desalting projects. Blending SWP and CRA supplies, or using the SWP’s relatively low TDS supplies for groundwater replenishment, is a strategy in some areas. However, some inland water districts that reuse wastewater have salt accumulation problems in their groundwater basins because they lack an ocean outfall or stream discharge. Other districts have established access to a brine line for exporting salt and concentrated wastes to a coastal treatment plant and ocean outfall, while others have not found construction of a brine line to be economical.

Beyond salinity, several established and emerging contaminants of concern to the region’s drinking water supplies include disinfection by-products (DBPs), perchlorate, arsenic, nitrosodimethylamine (NDMA), hexavalent chromium and methyl tertiary butyl ether (MTBE). Historically, industrial solvents have extensively impacted the groundwater underlying the San Gabriel Valley. Imported water from the
Owens Valley is of excellent water quality, and imported Delta water quality is generally good. Nonetheless, arsenic is a concern in the Owens Valley supply, and Delta water can contain precursors—such as organic carbon and bromide—of potentially carcinogenic disinfection by-products, if treated with certain beneficial disinfection processes necessary to inactivate pathogens in drinking water. Perchlorate, a component of rocket fuel that can disrupt thyroid gland function, has particularly impacted the groundwater in Pasadena and the Rialto-Colton-Fontana region. Perchlorate is also a concern in Colorado River water, largely due to contamination from inactive ammonium perchlorate manufacturing facilities in Nevada. Perchlorate contamination of wells in the San Gabriel Valley, which resulted in the deactivation of many of these wells, has led to testing of ion exchange technologies for the removal of this constituent.

Naturally occurring arsenic, a known human carcinogen, is another contaminant of concern, present in the LAA supply as well as local aquifers. The city of Los Angeles currently manages arsenic concentrations in LAA water through treatment and exchanges with MWD. In southern California, local water sources with high arsenic levels are found in Los Angeles, San Bernardino, and Riverside counties.

NDMA, a probable human carcinogen, is associated with the production of rocket fuel, and the manufacture of explosives, paints, and other industrial goods. Contamination of surface and groundwater by NDMA at missile and rocket fuel manufacturing and storage sites is a significant concern, particularly for groundwater supplies. NDMA can also be formed during the treatment of wastewater, which is a threat to aquifers that are recharged with reclaimed wastewater and later used for drinking water.

Groundwater contamination by hexavalent chromium, a suspect carcinogen better known as chromium 6, in the Los Angeles basin and elsewhere, has resulted from its use in various industries including aerospace and plating. In Los Angeles County, Los Angeles Water Board staff is overseeing assessment and cleanup of sites impacted by hexavalent chromium at defense-related businesses and manufacturing and other industrial sites.

MTBE and other oxygenates have been added to gasoline in areas with severe air pollution to help gasoline burn more cleanly and comply with federal law. MTBE can contaminate groundwater when pipelines, fuel tanks, and other containers or equipment leak, when fuel is spilled, and when unburned fuel is discharged from watercraft. The high mobility and low biodegradability of MTBE presents a significant risk to aquifer supplies. MTBE has been widely detected in South Coast groundwater, surface water, and imported water supplies. In particular, MTBE has limited the use of most of Santa Monica’s wells, making the city more dependent upon imported water and treatment systems.

Groundwater quality issues are being addressed in the region. In the San Gabriel Valley, the Main San Gabriel Basin Watermaster, San Gabriel Basin Water Quality Authority, Upper San Gabriel Valley Municipal Water District, and a number of water suppliers have actively pursued technical remedies for the groundwater quality problems described earlier. Several treatment facilities for the VOCs were first constructed in the 1990s. As of June 2002, 18 treatment facilities are operational. Groundwater supplies with high nitrate levels are either blended with other supplies or not used at all. Similar cleanup efforts are being pursued in the San Fernando Basin by LADWP and the Upper Los Angeles River Basin Watermaster. Several groundwater desalting plants are currently operated by the Santa Ana Water Project Authority (SAWPA), Chino Basin Desalting Authority, city of Corona, Eastern Municipal Water District’s, Irvine Ranch Water District, the city of Oceanside, West Basin MWD, and the Sweetwater...
Authority. Brackish groundwater desalting delivers about 100,000 acre-feet of water today and will increase to approximately 250,000 acre-feet during the next decade. Proposition 13 water bond funding is being used to expand desalting capacity in the region.

The SAWPA is a joint powers authority located in the eastern portion of the region. It represents five agencies in the counties of Orange, Riverside, and San Bernardino and covers a watershed area of 2,650 square miles. It provides effective and concerted watershed planning on a regional basis. In addition, SAWPA operates a brine disposal line, which facilitates disposal of waste brine from regional desalting plants and operates the Arlington Desalter. SAWPA has been particularly successful in recent years in assisting its member agencies in implementing several new water resources projects that enhance groundwater recovery, groundwater storage, water quality improvement and water recycling through the use of Proposition 13 Water Bond funding. Approximately 20 potential groundwater recovery projects were evaluated with a net yield of 95,000 acre-feet per year.

The Port Hueneme Water Agency was formed to develop and operate a brackish water desalting demonstration facility for its member agencies in western Ventura County. Its goals are to improve the quality and reliability of local groundwater supplies and decrease seawater intrusion in the Oxnard Plain. The facility will provide a full-scale demonstration of side-by-side operation of three brackish water desalting technologies: reverse osmosis, nanofiltration, and electrodialysis reversal.

**Colorado River**

The Salton Sea, with its increasing salinity, selenium, and eutrophication, is the primary focus of water quality issues in the Colorado River region. The largest sources of the Sea’s inflow are the New and Alamo Rivers and the Imperial Valley agriculture drains, which contribute pesticides, nutrients, selenium, and silt. The New River, the most polluted river in the US, actually originates in Mexicali, Mexico, flows across the International Boundary, through the city of Calexico, and then northward, emptying into the Salton Sea. It conveys urban runoff, untreated and partially treated municipal and industrial wastes, and agricultural runoff from the Mexicali and Imperial Valleys. These pollution sources contribute pesticides, pathogens, silt, nutrients, trash, and VOCs (the latter, primarily from Mexican industry) to the Sea. Both the Alamo River, which originates just two miles south of the border and also flows northward to the Salton Sea, and the Coachella Valley Stormwater Channel, which flows southward to the Sea, consist mainly of agricultural return flows from the Imperial and Coachella Valleys, respectively. Both the Coachella Valley Stormwater Channel and the Palo Verde Outfall Drain, which also drains to the sea, are heavily contaminated with pathogens.

Contamination in the Salton Sea presents threats to migrating birds on the Pacific Flyway. At some times of the year, nutrient loading to the Sea supports large algal blooms that contribute to odors, as well as low dissolved oxygen levels that adversely affect fisheries. Selenium is a more recent constituent of interest, potentially affecting fish and wildlife.

The relatively saline Colorado River provides irrigation and domestic water to much of southern California. Of recent human health concern, though, are the presence of low levels of perchlorate in the Colorado River (from a Kerr-McGee chemical facility in the Las Vegas Wash, the nation’s largest perchlorate contamination site), and high levels of hexavalent chromium in wells near Needles, from a PG&E Topock natural gas compressor station. Septic systems at recreational areas along the Colorado are also a concern for domestic and recreational water uses. Other important water quality issues in this
region include increasing levels of salinity, nitrates and other substances in groundwater associated with animal feeding and dairy operations and septic tank systems, especially in the Desert Hot Springs area and in the Cathedral City Cove area. In the Coachella Valley, nitrates have restricted the use of several domestic water supply wells.
### Appendix 1: Basin Plan Adoption Dates

<table>
<thead>
<tr>
<th>Region</th>
<th>Latest Basin Plan</th>
<th>Amendments</th>
<th>Triennial Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Los Angeles</td>
<td>1994</td>
<td>1998; 1999 (2); 2001 (3); 2002 (4); 2003 (7); 2004 (5)</td>
<td>2001</td>
</tr>
<tr>
<td>5. Tulare Lake</td>
<td>2004</td>
<td>none</td>
<td>2002</td>
</tr>
<tr>
<td>7. Colorado</td>
<td>1993</td>
<td>2001 (2); 2002 (2); 2004</td>
<td>2002</td>
</tr>
</tbody>
</table>

7These amendments were not included in the 2004 basin plan because they had not yet been fully approved by the various approving agencies and were therefore not effective.
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Glossary

A
acre-foot (af) – The volume of water that would cover one acre to a depth of one foot; equal to 43,560 cubic feet or 325,851 gallons.

adjudication – The act of judging or deciding by law. In the context of an adjudicated groundwater basin, landowners or other parties have turned to the courts to settle disputes over how much groundwater can be extracted by each party to the decision.

agricultural discharge standards – State and federal water quality regulations regarding discharge of water used for agricultural production to streams, rivers, groundwater aquifers, or evaporation ponds. Context: Scenario Factor.


agriculture water reliability (average) – A measure of a water system’s ability to sustain the social, environmental, and economic agricultural systems that it serves during a year of average precipitation.

agricultural water use efficiency – The ratio of applied water to the amount of water required to sustain agricultural productivity. Efficiency is increased through the application of less water to achieve the same beneficial productivity or by achieving more productivity while applying the same amount of water. Context: Scenario Factor, Resource Management Strategy.

allocation of long-term contractual imports – Interregional allocation of water for periods of time more than one year through mechanisms such as the State and federal water projects. Context: Scenario Factor.

alluvial – Of or pertaining to or composed of alluvium.

alluvium – A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material, deposited during comparatively recent geologic time by a stream or other body of running water, as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, as a cone or fan at the base of a mountain slope.

anthropogenic – Of human origin or resulting from human activity.

applied water – The amount of water from any source needed to meet the demand for beneficial use by the user. It includes consumptive use, reuse, and outflows.

applied water reduction – A decrease in the amount of water needed to meet the demand for beneficial use; can be a supply for both new (real) water and reused water. Context: Resource Management Strategy. See also new water.

appropriative right – The right to use water that is diverted or extracted by a nonriparian or nonoverlying party for nonriparian or nonoverlying beneficial uses. In California, surface water appropriative rights are subject to a statutory permitting process while groundwater appropriation is not.

aquifer – A body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant (i.e. economic) quantities of groundwater to wells and springs.

aquifer remediation – See groundwater remediation/aquifer remediation.

aquitard – A confining bed or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores groundwater.
artesian aquifer — A body of rock or sediment containing groundwater that is under greater than hydrostatic pressure; that is, a confined aquifer. When an artesian aquifer is penetrated by a well, the water level will rise above the top of the aquifer.

artesian pressure — Hydrostatic pressure of artesian water, often expressed in terms of pounds per square inch; or the height, in feet above the land surface, of a column of water that would be supported by the pressure.

artificial recharge — The (intentional) addition of water to a groundwater reservoir by human activity, such as putting surface water into dug or constructed spreading basins or injecting water through wells.

available groundwater storage capacity — The volume of a groundwater basin that is unsaturated and capable of storing groundwater.

available soil water — The amount of water held in the soil that can be extracted by a crop; often expressed in inches per foot of soil depth. It is the amount of water released between in situ field capacity and the permanent wilting point.

average annual cost of implementing option — Annualized total monetary cost of option required for “turn key” implementation including environmental and third party impact mitigation, storage, conveyance, energy, capitalized operations and maintenance, administrative, planning, legal and engineering costs. Context: Evaluation Criteria; Planning Concept/Consideration.

average annual runoff — The average value of total annual runoff volume calculated for a selected period of record, at a specified location, such as a dam or stream gage.

average year water demand — Demand for water under average hydrologic conditions for a specific level of development.

basin irrigation — Irrigation by flooding areas of level land surrounded by dikes. Used interchangeably with level border irrigation, but usually refers to smaller areas.

basin management objectives (BMOs) — See management objectives

beneficial use — Use of water either directly by people or for their overall benefit. There are 24 categories of beneficial uses identified by the State Water Resources Control Board.

border irrigation — Irrigation by flooding strips of land, rectangular in shape and cross leveled, bordered by dikes. Water is applied at a rate sufficient to move it down the strip in a uniform sheet. Border strips having no downfield slope are referred to as level border systems. Border systems constructed on terraced lands are commonly referred to as benched borders.

catastrophic vulnerability — The probability and magnitude of potential negative economic, public health, and environmental impacts associated with water management actions. Context: Scenario Factor; Evaluation Criteria.

Central Valley Project deliveries — The volume of water imported to a given area through the Central Valley Project. Context: Scenario Factor.

check irrigation — Modification of a border strip with small earth ridges or restrictions (checks) constructed or inserted at intervals to retain water as it flows down the strip.
CIMIS – California Irrigation Management Information System: A network of automated weather stations that are owned and operated cooperatively between the DWR and local agencies. The stations are installed in most of the agricultural and urban areas in the State and provide farm and large landscape irrigation managers and researchers with “real-time” weather data to estimate crop and landscape ET rates and make irrigation management decisions.

climate change – Changes in average annual temperature and precipitation and their monthly patterns in 2050 compared to today.

Colorado River supply – The volume of water California has the right to import from the Colorado River. California’s allocation is 4.4 million acre-feet per year plus 50% of any declared surplus. Context: Scenario Factor.

commercial activity mix – The mix of high- and low-water using commercial activity. Note that commercial activity is broken into two factors: total commercial activity and commercial activity mix. The latter factor allows designation of the type of commercial activity that is occurring. See also total commercial activity. Context: Scenario Factor.

community water system – A public water system that serves at least 15 service connections used by yearlong residents or regularly serves at least 25 yearlong residents. See also public water system.

consumed fraction – the portion of agricultural applied irrigation water that satisfies evapotranspiration.

conveyance – Provides for the movement of water and includes the use of natural and constructed facilities including open channels, pipelines, diversions, fish screens distribution systems and pump lifts.

conveyance facilities – Canals, pipelines, pump lifts, ditches, etc. used to move water from one area to another. Context: Study Plan Building Block, Resource Management Strategy.

confined aquifer – An aquifer that is bounded above and below by formations of distinctly lower permeability than that of the aquifer itself. An aquifer containing confined groundwater. See also artesian aquifer.


conjunctive use – Application of surface and groundwater to meet the demand for a beneficial use. Coordinated and planned management of both surface and groundwater resources in order to maximize the efficient use of the resource; that is, the planned and managed operation of a groundwater basin and a surface water storage system combined through a coordinated conveyance infrastructure. Water is stored in the groundwater basin for later and planned use by intentionally recharging the basin during years of above-average surface water supply.

conservation tillage – A tillage practice that leaves plant residues on the soil surface for erosion control and moisture conservation

consumptive use – A quantity of applied water that is not available for immediate or economical reuse. It includes water that evaporates, transpires, or is incorporated into products, plant tissue, or animal tissue. Consumptively used water is removed from available supplies without return to a water resource system (uses such as manufacturing, agriculture, landscaping, food preparation, and in the case of Colorado River water, water that is not returned to the river.)

contaminant – Any substance or property preventing the use or reducing the usability of the water for ordinary purposes such as drinking, preparing food, bathing washing, recreation, and cooling. Any solute or cause of change in physical properties that renders water unfit for a given use. (Generally considered synonymous with pollutant.)
cost recovery – Designates who (marginal or existing users) pays the marginal and existing water costs. Also specifies circumstances where other revenue sources are used to recover costs. Costs can include capital, O&M, financing, environmental compliance (documentation, permitting and mitigation), etc. Context: Scenario Factor


critical conditions of overdraft – A groundwater basin in which continuation of present practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts. The definition was created after an extensive public input process during the development of the Bulletin 118-80 report.

cover crop – Close growing crop, that provides soil protection, seeding protection, and soil improvement between periods of normal crop production, or between trees in orchards and vines in vineyards. When plowed under and incorporated into the soil, cover crops may be referred to as green manure crops.

crop coefficient – A numerical factor (normally identified as Kp or Kc) that relates the evapotranspiration (ET) of the individual crop (Etc) to reference evaporation or some other index.

crop idling – The temporary or permanent fallowing of land previously under irrigation that results in a reduction in stresses to a water system (e.g., alternate land use must result in a reduction in water use and/or enhancement of water quality, etc.). Context: Scenario Factor.

crop rotation – A system of farming in which a succession of different crops are planted on the same land area, as opposed to growing the same crop time after time (monoculture).

crop unit water use – The volume of irrigation water used per unit area of land, commonly expressed in acre feet per acre. As used in scenario evaluation, a change in unit water use can be a function of evapotranspiration rates and cultural practices, but NOT use efficiency. Agricultural use efficiency is captured under its own distinct factor. Context: Scenario Factor.

D

depth – Percolation of water through the ground and beyond the lower limit of the root zone of plants into groundwater.

depth of water and groundwater – Water that is applied for agricultural, urban, and managed wetlands in excess of the net use requirements. Water either is applied for groundwater recharge or percolates naturally to the water table. This does not include reuse, evaporation, evapotranspiration of applied water, or flows/percolation to a salt sink. Context: Water Portfolio.

deployment – Water consumed through evapotranspiration, flows to salt sinks or is otherwise no longer available as a source supply.

desalination – Water treatment process for the removal of salt from water for beneficial use. Source water can be brackish (low salinity) or seawater. Context: Study Plan Building Block.


distribution system – System of ditches or conduits and their controls that conveys water from the supply canal to the farm points of delivery.
domestic well – A water well used to supply water for the domestic needs of an individual residence or systems of four or fewer service connections.

drinking water standards – State and federal regulations regarding water delivered by water purveyors that is used as a potable supply. Context: Scenario Factor.

drinking water system – see public water system

drinking water treatment and distribution – Treatment is the physical, biological and chemical processes that make water suitable for potable use. Distribution includes storage, pumping, and pipe systems to protect and deliver the treated water to customers. Context: Study Plan Building Block.

drip irrigation – A method of micro irrigation wherein water is applied to the soil surface as drops or small streams through emitters. Discharge rates are generally less than 8 L/h (2 gal/h) for a single-outlet emitters and 12 L/h (3 gal/h) per meter for line-source emitters.

drought preparedness – The magnitude and probability of economic, social or environmental consequences that would occur as a result of a sustained drought under a given study plan. Evaluation criteria measure the “drought tolerance” of study plans. Context: Water Management Objective

drought condition – Hydrologic conditions during a defined period, greater than one dry year, when precipitation and runoff are much less than average.

drought year supply – The average annual supply of a water development system during a defined drought period.

duty of water – The total volume of irrigation water required to mature a particular type of crop. It includes consumptive use, evaporation, and seepage as well as the water returned to streams by percolation and surface water.

E
earthquake vulnerability – see seismic vulnerability

economic incentives – Financial assistance and pricing policies intended to influence water management including, for example, amount of use, time of use wastewater volume, and source of supply. Context: Resource Management Strategy.


effective precipitation – That portion of precipitation that supplies crop evapotranspiration. It includes precipitation stored in the soil before and during the growing season

effective porosity – The volume of voids or open spaces in alluvium and rocks that is interconnected and can transmit fluids.

effective rooting depth – The depth from which soil moisture is extracted; it is determined by the crop rooting characteristics and soil depth limitations.

electrical conductivity (EC) – The measure of the ability of water to conduct an electrical current, the magnitude of which depends on the dissolved mineral content of the water.
energy availability – The energy consumption to facilitate water management-related actions such as desalting, pump-storage, groundwater extraction, conveyance or treatment. This criterion pertains to the economic feasibility of a proposed water management action in terms of O&M costs. Context: Evaluation Criteria.

groundwater extraction, conveyance or treatment. This criterion pertains to the economic feasibility of a proposed water management action in terms of O&M costs. Context: Evaluation Criteria.

energy costs – Refers to the cost of energy use related to producing, conveying and applying water. It also refers to the cost of energy use for processes and inputs not directly related to water, but which can affect the demand for water (e.g., the cost of nitrogen fertilizer, tractor manufacturing, etc.). Context: Scenario Factor.

energy production – Both instantaneous capacity (megawatt) and energy produced (kilowatt hours). Context: Evaluation Criteria.

environmental justice – The fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. (Section 65040.12. (c) Government code)

environmental water (flow based) – The amount of water dedicated to instream fishery uses, Wild and Scenic rivers, Bay-Delta outflow and aquatic habitat.

environmental water (land based) – The amount of water used for fresh-water managed wetlands and native vegetation.

environmental water quality – Water quality in terms of ecosystem health, recreation, salinity intrusion, usability per sector, treatment costs, etc. Aquatic species and water bodies are vulnerable to changes to water quality.

ETo (Reference Evapotranspiration) – The evapotranspiration rate from an extended surface of 3 to 6 inch (8–15 cm) tall green grass cover of uniform height, actively growing, completely shading the ground, and not short on water (the reference ET reported by CIMIS).

evaluation criteria – The technical information that will be used to compare the favorability of different response packages of resource management strategies against future scenarios in California Water Plan Update 2010. They are designed to identify and measure potential effects on water supply, the environment, energy use or production, recreational opportunities, groundwater overdraft, and many more.

evaporation – The physical process by which a liquid or solid is transformed to a gaseous state.

evaporative demand – The collective influence of all climatic factors on the rate of evaporation of water.

evapotranspiration (ET) – The quantity of water transpired by plants, retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces

evapotranspiration of applied water (ETAW) – The portion of ET satisfied by applied irrigation water.

F

flood irrigation – Method of irrigation where water is applied to the soil surface without flow controls, such as furrows, borders, or corrugations

floodplain management – Actions designed to reduce risks to life, property, and the environment due to flooding. Actions can include watershed management, infrastructure construction and operation, variations in land use practices, floodway designations, etc. Context: Study Plan Building Block.
flood risk – The magnitude and probability of consequences that would occur as a result of flood-induced infrastructure damage under a given study plan. Context: Evaluation Criteria.

flow diagram – Diagram that characterizes a region’s hydrologic cycle by documenting sources of water such as precipitation and inflows and tracks the water as it flows (through many different uses) to its ultimate destinations.

flow diagram table – An itemized listing of all the categories contained in the Flow Diagram including more detailed information, organized by “inputs” and “withdrawals.”

full cost – (1) all monetary costs associated with project planning, implementation, financing, or impact mitigation plus any recurring costs required to sustain benefits; PLUS (2) all nonmonetary costs that are incurred either at implementation or on a recurring basis such as unmitigable environmental or cultural impacts, public trust, environmental justice, or other nonmarket-based societal values. (Coincides with CEQA/NEPA study and other permitting requirements.) Context: Planning Concept/Consideration.

furrow irrigation – Method of surface irrigation where the water is supplied to small ditches or furrows for guiding across the field.

G
groundwater – Water that occurs beneath the land surface and fills the pore spaces of the alluvium, soil, or rock formation in which it is situated. It excludes soil moisture, which refers to water held by capillary action in the upper unsaturated zones of soil or rock.

groundwater basin – An alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and having a definable bottom.

groundwater budget – A numerical accounting, the groundwater equation, of the recharge, discharge and changes in storage of an aquifer, part of an aquifer, or a system of aquifers.

groundwater in storage – The quantity of water in the zone of saturation.

groundwater management – The planned and coordinated management of a groundwater basin or portion of a groundwater basin with a goal of long-term sustainability of the resource.

groundwater management plan – A comprehensive written document developed for the purpose of groundwater management and adopted by an agency having appropriate legal or statutory authority.

groundwater mining – The process, deliberate or inadvertent, of extracting groundwater from a source at a rate in excess of the replenishment rate such that the groundwater level declines persistently, threatening exhaustion of the supply or at least a decline of pumping levels to uneconomic depths.

groundwater monitoring network – A series of monitoring wells at appropriate locations and depths to effectively cover the area of interest. Scale and density of monitoring wells is dependent on the size and complexity of the area of interest, and the objective of monitoring.

groundwater overdraft – The condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average conditions.
groundwater quality – See water quality

groundwater recharge facility – A structure that serves to conduct surface water into the ground for the purpose of replenishing groundwater. The facility may consist of dug or constructed spreading basins, pits, ditches, furrows, streambed modifications, or injection wells.

groundwater recharge – The natural or intentional infiltration of surface water into the zone of saturation.

groundwater remediation/aquifer remediation – Groundwater Remediation involves extracting contaminated groundwater from an aquifer, treating it, and then either putting it back in the aquifer or using it for agricultural or municipal purposes. Aquifer Remediation is usually accomplished by treating groundwater while it is still in the aquifer, using in-situ methods involving biological, physical, or chemical treatment or electrokinetics. Context: Study Plan Building Block, Resource Management Strategy.

groundwater source area – An area where groundwater may be found in economically retrievable quantities outside of normally defined groundwater basins, generally referring to areas of fractured bedrock in foothill and mountainous terrain where groundwater development is based on successful well penetration through interconnecting fracture systems. Well yields are generally lower in fractured bedrock than wells within groundwater basins.

groundwater storage capacity – Volume of void space that can be occupied by water in a given volume of a formation, aquifer, or groundwater basin.

groundwater subbasin – A subdivision of a groundwater basin created by dividing the basin using geologic and hydrologic conditions or institutional boundaries.

groundwater table – The upper surface of the zone of saturation in an unconfined aquifer.

groundwater quality – Water quality can affect supply integrity. Many pollutants are hydrophilic and not easily filtered by soil. Treated groundwater can be added to water supply. Context: Evaluation Criteria.

H
hazardous waste – Waste that poses a present or potential danger to human beings or other organisms because it is toxic, flammable, radioactive, explosive, or has some other property that produces substantial risk to life.

hydraulic barrier – A barrier created by injecting fresh water to control seawater intrusion in an aquifer, or created by water injection to control migration of contaminants in an aquifer.

hydraulic conductivity – A measure of the capacity for a rock or soil to transmit water; generally has the units of feet/day or cm/sec.

hydrograph – A graph that shows some property of groundwater or surface water as a function of time at a given point.

hydrology – A science related to the occurrence and distribution of natural water on the earth including the annual volume and the monthly timing of runoff.

hydrologic cycle – The circulation of water from the ocean through the atmosphere to the land and ultimately back to the ocean.
hydrologic region – A study area consisting of multiple planning subareas. California is divided into 10 hydrologic regions.

hydrostratigraphy – A geologic framework consisting of a body of rock having considerable lateral extent and composing a reasonably distinct hydrologic system.

hyporheic zone – The region of saturated sediments beneath and beside the active channel and that contain some proportion of surface water that was part of the flow in the surface channel and went back underground and can mix with groundwater.

in-lieu recharge – The practice of providing surplus surface water to historic groundwater users, thereby leaving groundwater in storage for later use.

industrial activity mix – The mix of high and low water using industrial activity. Note that Industrial Activity is broken into two factors: Total Industrial Activity and Industrial Activity Mix. The latter factor allows designation of the type of industry that is occurring. This is necessary to account for the large variation in water demands by industry type. See also total industrial activity. Context: Scenario Factor.

infiltration – The flow of water downward from the land surface into and through the upper soil layers.

infiltration capacity – The maximum rate at which infiltration can occur under specific conditions of soil moisture.

infrastructure – the underlying foundation or basic framework of a system

integrated regional water management – A comprehensive, systems approach for determining the appropriate mix of demand and supply management options that provide long-term, reliable water supply at lowest reasonable cost and with highest possible benefits to customers, economic development, environmental quality, and other social objectives.

intercropping – The simultaneous planting of two or more crops in the same field. The practice is used to help control pest populations that can occur on monoculture crops, sometimes called “polycropping” or “plant stratification.”

interregional import projects – Movement of water between regions through mechanisms such as the State and federal water projects. Context: Scenario Factor.

irrecoverable water – the amount of applied water that is not available for supply or reuse, including discharge to saline sinks, evaporation, and evapotranspiration. See recoverable water

irrigation efficiency (IE) – The efficiency of water application and use, calculated by dividing a portion of applied water that is beneficially used by the total applied water, expressed as a percentage. The two main beneficial uses are crop water use (evapotranspiration, etc) and leaching to maintain a salt balance.

irrigation water requirements – The quantity of water exclusive of precipitation that is required from various uses.

joint powers agreement (JPA) – An agreement entered into by two or more public agencies that allows them to jointly exercise any power common to the contracting parties. The JPA is defined in Ch. 5 (commencing with Section 6500) of Division 7 of Title 1 of the California Government Code.
land subsidence — The lowering of the natural land surface due to groundwater (or oil and gas) extraction.

leaching requirements — The fraction of water entering the soil that must pass through the root zone in order to prevent soil salinity from exceeding a specific value.

leaching efficiency — The ratio of the average salt concentration in drainage water to an average salt concentration in the soil water of the root zone when near field capacity.

leaky confining layer — A low-permeability layer that can transmit water at sufficient rates to furnish some recharge from an adjacent aquifer to a well.

lithologic log — A record of the lithology of the soils, sediments and/or rock encountered in a borehole from the surface to the bottom.

lithology — The description of rocks, especially in hand specimen and in outcrop, on the basis of such characteristics as color, mineralogic composition, and grain size.

management objectives — Objectives that set forth the priorities and measurable criteria of water management. Examples include improve water quality, augment water supplies, improve use efficiency, etc.

matching water quality to use — A resource management strategy that recognizes not all water uses require the same quality water. High quality water sources can be used for drinking and industrial purposes that benefit from higher quality water, and lesser quality water can be desirable for some uses, such as riparian streams with plant materials benefiting fish. Context: Resource Management Strategy.

maximum contaminant level (MCL) — The highest drinking water contaminant concentration allowed under federal and State Safe Drinking Water Act regulations.

microirrigation — The frequent application of small quantities of water as drops, tiny streams, or miniature spray through emitters or applicators placed along a water delivery line. Microirrigation encompasses a number of methods or concepts such as bubbler, drip, trickle, mist, or spray.

multicropping — The practice of consecutively producing two crops (double cropping) or more of either like or unlike com modities on the same land within the same year. An example of double cropping might be to harvest a wheat crop by early summer and then plant corn or beans on that acreage for harvest in the fall. Suitable climates and reliable water supplies are important factors with this practice.

naturally occurring conservation — The amount of background conservation occurring independent of the BMP and EWMP programs (e.g., plumbing codes, etc.). Context: Scenario Factor.

natural recharge — Natural replenishment of an aquifer generally from snowmelt and runoff; through seepage from the surface.

net groundwater withdrawal — Groundwater extraction in excess of percolation into a groundwater basin. Context: Water Portfolio
net water use (demand) – the amount of water needed in a water service area to meet all requirements or demands. It is the sum of several components including evapotranspiration of applied water in an area, the irrecoverable water from the distribution system, and the outflow leaving the service area; does not include reuse of water within a service area.

new water – Water that is legally and empirically available for a beneficial use; can be developed through many strategies such as capturing surplus water, desalination of ocean water and reductions in depletions. (Same meaning as real water)
Context: Planning Concept/Consideration.

nonpoint source – Pollution discharged over a wide land area, not from one specific location. These are forms of diffuse pollution caused by sediment, nutrients, etc., carried to lakes and streams by surface runoff. See also point source

operational flexibility – The temporal or spatial operational efficiency of existing and proposed infrastructure to maximize benefits. Context: Evaluation Criteria.

operational yield – An optimal amount of groundwater that should be withdrawn from an aquifer system or a groundwater basin each year. It is a dynamic quantity that must be determined from a set of alternative groundwater management decisions subject to goals, objectives, and constraints of the management plan.

ordinance – A law set forth by a governmental authority.

other interregional import deliveries – This factor is intended to capture the interregional movement of water for “projects” such as Russian River, Trinity River Exports or Putah South Canal. Note that the project name must be specified in the study plan narrative. Context: Scenario Factor.

overdraft – See groundwater overdraft

overlying right – Property owners above a common aquifer possess a mutual right to the reasonable and beneficial use of a groundwater resource on land overlying the aquifer from which the water is taken. Overlying rights are correlative (related to each other) and overlying users of a common water source must share the resource on a pro rata basis in times of shortage. A proper overlying use takes precedence over all non-overlying uses.

pelagic fish – fish that spawn in open water, often near the surface. Many river-dwelling anadromous fishes, such as shad are also pelagic spawners

perched groundwater – Groundwater supported by a zone of material of low permeability located above an underlying main body of groundwater.

percolation – Process in which water moves through a porous material, usually surface water migrating through soil toward a groundwater aquifer.

perennial yield – The maximum quantity of water that can be annually withdrawn from a groundwater basin over a long period of time (during which water supply conditions approximate average conditions) without developing an overdraft condition.

permeability – The capability of soil or other geologic formations to transmit water.
pesticide – Any of a class of chemicals used for killing insects, weeds, or other undesirable entities. Most commonly associated with agricultural activities, but has significant domestic use in California.

point source – A specific site from which wastewater or polluted water is discharged into a water body. See also nonpoint source

pollution (of water) – The alteration of the physical, chemical, or biological properties of water by the introduction of any substance into water that adversely affects any beneficial use of water.

pollution prevention – Improving water quality for all beneficial uses by protecting water at its source, reducing the need and cost for other water management actions and treatment. Context: Resource Management Strategy.

population density – The average number of people per square mile for a planning area. Context: Scenario Factor.

population distribution – The geographic location within California of the population projection. Context: Scenario Factor.

population projection – The 2030 forecast of population made by the California Department of Finance or other agencies. Context: Scenario Factor.

porosity – The ratio of the voids or open spaces in alluvium and rocks to the total volume of the alluvium or rock mass.

possible contaminating activity (PCA) – Human activities that are actual or potential origins of contamination for a drinking water source. PCAs include sources of both microbiological and chemical contaminants that could have an adverse effect upon human health.


prescriptive right – Rights obtained through the open and notorious adverse use of another’s water rights. By definition, adverse use is not use of a surplus, but the use of non surplus water to the direct detriment of the original rights holder.

public trust doctrine – A legal doctrine recognizing public rights in the beds, banks, and waters of navigable waterways, and the State’s power and duty to exercise continued supervision over them as trustee for the benefit of the people.

public water system – A system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year.

pueblo right – A water right possessed by a municipality which, as a successor of a Spanish or Mexican pueblo, entitled to the beneficial use of all needed, naturally occurring surface and groundwater of the original pueblo watershed. Pueblo rights are paramount to all other claims.

R

rate structure – Designates the rate basis for cost recovery (e.g., flat, uniform, tiered, etc.). Block/Tiered rates are assumed to provide cost signals to consumers. Costs can include capital, O&M, financing, environmental compliance (documentation, permitting and mitigation), etc. Context: Scenario Factor.

recharge – Water added to an aquifer or the process of adding water to an aquifer. Groundwater recharge occurs either naturally as the net gain from precipitation or artificially as the result of human influence. See also artificial recharge.

recharge area protection – The action of keeping recharge areas from being paved over or otherwise developed and guarding the recharge areas so they don’t become contaminated Context: Resource Management Strategy.

recharge basin – A surface facility constructed to infiltrate surface water into a groundwater basin.

recoverable water – the amount of applied water that is available for supply or reuse; including surface runoff to non-saline bodies of water and deep percolation that becomes groundwater. See irrecoverable water

recreation – Water-dependent recreation activities that are consumptive (e.g., parks), flat-water (e.g., boating), or flow-based (e.g., whitewater rafting). Context: Scenario Factor.

recreation (reservoir-based) – Flat water recreation, such as boating and skiing, in the form of future storage facilities as well as operation of existing surfaces storage facilities. Context:

recreation sport-fish populations – Populations of fish species that support recreational fishing.

recreation (watercourse-based) – Activities that are dependent on instream flows such as whitewater rafting. Context:

recycled water – Treated municipal, industrial, or agricultural wastewater to produce water that can be reused. Context: Resource Management Strategy


reliability planning – Water reliability management planning is done by comparing the costs of taking actions to maintain or increase reliability to the costs of accepting less reliability. On this basis, accepting of the costs of adverse effects of less than 100 percent reliability could be a legitimate planning decision. Providing full water supply to meet 100 percent of projected future water demand is not the planning goal, rather, the goal is to find the justified level of reliability. Context: Planning Concept/Consideration.

resource management strategy – A project, program, or policy that helps federal, State or local agencies manage water and related resources. Resource Management Strategies can reduce water demand, improve operational flexibility, increase water supply, improve water quality, or practice resource stewardship.

response packages – Additional sets of resource management strategies to be tested against future scenario conditions for performance comparison. This analysis will take place in California Water Plan Update 2010. Comparing the performance of different response packages will provide useful information to decision-makers and water managers as they choose actions to achieve a desirable future water condition.

return-flow system – A system of pipelines or ditches to collect and convey surface or subsurface runoff from an irrigated field for reuse.

reused agricultural water – Water that is used by more than one grower and is, therefore, not available for reallocation should one grower become increasingly efficient (i.e., applied water reductions minus real water equal zero). Context: Planning Concept/Consideration.
riparian right – A right to use surface water, such right derived from the fact that the land in question abuts the banks of streams.

root zone – The portion of the soil profile through which plant roots readily penetrate to obtain water and plant nutrients, expressed in inches or feet of depth.

runoff – The volume of surface flow from an area.

S
safe yield – The maximum quantity of water that can be continuously withdrawn from a groundwater basin without adverse effect

saline soil – A nonalkali soil containing soluble salts in such quantities that they interfere with the growth of most plants.

saline intrusion – The movement of salt water into a body of fresh water. It can occur in either surface water or groundwater bodies.

salinity – Generally, the concentration of mineral salts dissolved in water. Salinity may be expressed in terms of a concentration or as electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water.

saturated zone – The zone in which all interconnected openings are filled with water, usually underlying the unsaturated zone.

scenarios – Sets of plausible future conditions based on different assumptions of factors such as population size, density, and distribution, per capita income, commercial and industrial activity, and crop area and water use. In California Water Plan Update 2005, the three scenarios for 2030 are strictly narrative and are “no action” (i.e., they do not reflect any additional resource management strategies in the form of response packages beyond those currently planned, such as new water efficiency programs).

seasonal vs. permanent crop mix – Shifts in crop type between seasonal and permanent. This factor depicts the diminished ability to reduce water use during times of increased water scarcity (due to shifting from seasonal to permanent crops). In other words, shortage losses increase when shifting from seasonal to permanent. Context: Scenario Factor.

seawater intrusion barrier – A system designed to retard, cease or repel the advancement of seawater intrusion into potable groundwater supplies along coastal portions of California. The system may be a series of specifically placed injection wells where water is injected to form a hydraulic barrier.

secondary porosity – Voids in a rock formed after the rock has been deposited; not formed with the genesis of the rock, but later due to other processes. Fractures in granite and caverns in limestone are examples of secondary openings.

seepage – The gradual movement of water into, through, or from a porous medium. Also, the infiltration of water into the soil from canals, ditches, laterals, watercourse, reservoir, storage facilities, or other body of water, or from a field.

semi-confined aquifer – A semi-confined aquifer or leaky confined aquifer is an aquifer that has aquitards either above or below that allow water to leak into or out of the aquifer depending on the direction of the hydraulic gradient.

service area – The geographic area served by a water agency.

soil moisture – The water in soils. Usually expressed as a percentage of the dry weight of the soil. Can also be expressed on a wet weight or a volume basis.
soil texture – Soil texture refers to the percentage of sand, silt, and clay particles in a soil. Sand, silt, and clay particles are defined by their size. Soil texture has important effects on soil properties. Water-holding capacity, drainage class, consistence, and chemical properties are just a few examples of properties that are affected by soil texture.

specific retention – The ratio of the volume of water a rock or sediment will retain against the pull of gravity to the total volume of the rock or sediment.

specific yield – the ratio of the volume of water a rock or soil will yield by gravity drainage to the total volume of the rock or soil.

spring – a location where groundwater flows naturally to the land surface or a surface water body.

sprinkler irrigation – Method of irrigation in which the water is sprayed, or sprinkled, through the air to the ground surface.

stakeholder – individuals or groups who can affect or be affected by an organization’s activities. or: Individuals or groups with an interest or “stake” in what happens as a result of any decision or action. Stakeholders do not necessarily use the products or receive the services of a program.

State Water Project deliveries – The volume of water imported to a given study area from the State Water Project. Context: Scenario Factor.

statewide water management systems – These include physical facilities (more than 1,200 State, federal, and local reservoirs, as well as canals, treatment plants, and levees), which make up the backbone of water management in California, and statewide water management programs, which include water-quality standards, monitoring programs, economic incentives, water pricing policies, and statewide water-efficiency programs such as appliance standards, labeling, and education.

strategic plan – The long-term goals of an organization or program and an outline of how they will be achieved (e.g., adopting specific strategies, approaches, and methodologies).

stratigraphy – The science of rocks. It is concerned with the original succession and age relations of rock strata and their form, distribution, lithologic composition, fossil content, geophysical and geochemical properties—all characters and attributes of rocks as strata—and their interpretation in terms of environment and mode of origin and geologic history.

stress irrigation – Management of irrigation water to apply less than enough water to satisfy the soil water deficiency in the entire root zone. (Preferred term is limited irrigation.)

subirrigation – Application of irrigation water below the ground surface by raising the water table to within or near the root zone.

subsurface drip irrigation – Application of water below the soil surface through emitters, with discharge rates generally in the same range as drip irrigation. This method of water application is different from and not to be confused with subirrigation where the root zone is irrigated by water table control.

surface irrigation – Irrigation in which the soil surface is used as the conduit, as in furrow and border irrigation, and as opposed to sprinkler, drip, and subirrigation.


surge irrigation – A surface irrigation technique wherein flow is applied to furrows (or less commonly, borders) intermittently during a single irrigation set.
subsidence – See land subsidence

subterranean stream – Subterranean streams “flowing through known and definite channels” are regulated by California’s surface water rights system.

surface supply – Water supply obtained from streams, lakes, and reservoirs.

surplus water – Water that is not being used directly or indirectly to benefit the environmental, agricultural or urban use sectors. Context: Planning Concept/Consideration.

sustainability – A specific resource that avoids complete depletion over a specified time horizon. The continued feasibility of a specified economic activity over a specified time horizon, usually influenced by management and policy actions. Context: Economic Activity.

system reoperation – Changing existing water system operation and management procedures or priorities to either meet competing beneficial uses or derive more total benefits from the water system by operating more efficiently. Context: Resource Management Strategy.

T

third party impacts – The occurrence of incidental economic impacts to parties not directly related to (impact-causing) water management actions. For example, agricultural land retirement can impact local tax revenues and/or labor conditions, etc. Context: Evaluation Criteria.

total capital cost – Total monetary cost of option required for “turn key” implementation including environmental and third party impact mitigation, storage, conveyance, energy, capitalized O&M, administrative, planning, legal and engineering costs. Context: Planning Concept/Consideration.

total commercial activity – The amount of commercial activity (e.g., employment, productivity, commercial land use, etc) that occurs in a given study area. This factor is a driver of (and indicator for) commercial water use and includes institutional water use (government offices, schools, etc.) as well. See also commercial activity mix. Context: Scenario Factor.

total industrial activity – The total amount of industrial activity (e.g., employment, productivity, industrial land use, etc) that occurs in a given study area. This factor is a driver of (and indicator for) industrial water use. Context: Scenario Factor.

total irrigated crop area – The total area of irrigated crops (by type) planted in a planning area during a given year. This number includes multiple cropping. Context: Scenario Factor.


transpiration – An essential physiological process in which plant tissues give off water vapor to the atmosphere.

U

unconfined aquifer – An aquifer which is not bounded on top by an aquitard. The upper surface of an unconfined aquifer is the water table.

underground stream – Body of water flowing as a definite current in a distinct channel below the surface of the ground, usually in an area characterized by joints or fissures. Application of the term to ordinary aquifers is incorrect.
unit applied water – The quantity of water applied to a specific crop per unit area (sometimes expressed in inches of depth).

unsaturated zone – The zone below the land surface in which pore space contains both water and air.

urban land use management – Planning for the housing and economic development needs of the growing population while providing for the efficient use of water and other resources.

urban runoff management – A broad series of activities to manage both storm water and dry weather runoff.

Urban Water Management Planning Act – Sections 10610 through 10657 of the California Water Code. The Act requires urban water suppliers to prepare urban water management plans which describe and evaluate sources of water supplies, efficient uses of water, demand management measures, implementation strategies and schedules, and other relevant information and programs within their water service areas. Urban water suppliers (CWC Section 10617) are either publicly or privately owned and provide water for municipal purposes, either directly or indirectly, to more than 3,000 customers or supply more than 3,000 acre-feet of water annually.

[urban] water reliability (average) – A measure of a system’s ability to sustain the social, environmental and economic systems that it serves during a year of average participation. Context: Evaluation Criteria.

[urban] water reliability (dry) – A measure of a system’s ability to sustain the social, environmental and economic systems that it serves during a dry year. Context: Evaluation Criteria.

[urban] water reliability (wet) – A measure of a system’s ability to sustain the social, environmental and economic systems that it serves during a wet year. Context: Evaluation Criteria.

urban water use efficiency – Methods or technologies resulting in the same beneficial residential, commercial, industrial, and institutional uses with less water or increased beneficial uses from existing water quantities. Context: Scenario Factor, Resource Management Strategy.

usable storage capacity – The quantity of groundwater of acceptable quality that can be economically withdrawn from storage.

V

volatile organic compound (VOC) – A manmade organic compound that readily vaporizes in the atmosphere. These compounds are often highly mobile in the groundwater system and are generally associated with industrial activities.

W

water bag transport/storage technology – Water diverted in areas that have unallocated fresh water supplies, storing the water in large inflatable bladders, and towing to an alternate coastal region. Context: Resource Management Strategy.

water balance – An analysis of the total developed/dedicated supplies, uses, and operational characteristics for a region.

water demand – The desired quantity of water that would be used if the water is available and a number of other factors such as price do not change. Demand is not static.

water demand elasticity – The desire to use water is based on a number of factors such as the intended use for the water, the price of water, and the cost of alternative ways to meet the intended use.
water portfolio – A picture of the water supply and use for a given year statewide or by region, subject to availability of data; includes the flow diagram, flow diagram table, water balances, and summary table.

water quality – Description of the chemical, physical, and biological characteristics of water; usually in regard to its suitability for a particular purpose or use.

water reliability (dry) – A measure of a system’s ability to sustain the social, environmental, and economic systems that it serves during a dry year.

water reliability (wet) – A measure of a system’s ability to sustain the social, environmental, and economic systems which it serves during a wet year.

water supply exports – The amount of water that a region transfers to another to meet needs. Context: Regional Reports.

water supply imports – The amount of water that needs to be brought in from other regions to meet needs. Context: Regional Reports.

water table – See groundwater table

water transfers – A temporary or long-term change in the point of diversion, place of use, or purpose of use due to a transfer or exchange of water or water rights. A more general definition is that water transfers are a voluntary change in the way water is usually distributed among water users in response to water scarcity. Context: Scenario Factor, Resource Management Strategy.

water year – A continuous 12-month period for which hydrologic records are compiled and summarized. Different agencies may use different calendar periods for their water years.

watershed – The land area from which water drains into a stream, river, or reservoir.

watershed management – The process of evaluating, planning, managing, restoring, and organizing land and other resource use within an area that has a single common drainage point. Context: Resource Management strategy.
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</tr>
<tr>
<td>Electrical conductivity</td>
<td>microsiemens per centimeter (µS/cm)</td>
<td>micromhos per centimeter (µmhos/cm)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>degrees Celsius (°C)</td>
<td>degrees Fahrenheit (°F)</td>
<td>(1.8°C)+32</td>
<td>0.56(°F-32)</td>
<td></td>
</tr>
</tbody>
</table>
ARNOLD SCHWARZENEGGER
Governor

MIKE CHRISMAN
Secretary for Resources
The Resources Agency

LESTER A. SNOW
Director
Department of Water Resources