California's Groundwater Update 2013

A Compilation of Enhanced Content for California Water Plan Update 2013

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State of California
Natural Resources Agency
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STATEWIDE GROUNDWATER UPDATE

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Acronyms and Abbreviations Used in This Chapter

AB	Assembly Bill
ACWA	Association of California Water Agencies
AWMP	agriculture water management plan
bgs	below ground surface
BMO	basin management objective
C2VSim	California Central Valley Groundwater-Surface Water Simulation Model
CAFO	combined animal feeding operation
CASGEM	California Statewide Groundwater Elevation and Monitoring
CDPH	California Department of Public Health
CVHM	Central Valley Hydrologic Model
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWS	community water system
DAU	detailed analysis unit
DPR	Department of Pesticide Regulation
DWR	California Department of Water Resources
GAMA	Groundwater Ambient Monitoring and Assessment Program
GIS	geographic information system
GWMP	groundwater management plan
ILRP	implementation of long-term irrigated lands regulatory program
InSAR	interferometric synthetic aperture radar
IRWM	integrated regional water management
LLNL	Lawrence Livermore National Laboratory
maf	million acre-feet
MCL	maximum contaminant level
msl	mean sea level
PA	planning area
ppb	parts per billion
RWQCB	regional water quality control board
SB	Senate Bill
SWN	State Well Numbering
SWRC	State Water Resources Control Board
taf	thousand acre-feet
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
UWMP	urban water management plan

Chapter 2. Statewide Groundwater Update

Groundwater resources play a key role in sustaining California's environmental, social, and economic conditions. Approximately 30 million people (80 percent of Californians) live in areas overlying alluvial groundwater basins. Some communities in California use very little groundwater, while many communities are 100-percent reliant upon groundwater. California has been identified as the leading groundwater user in the United States, with its aquifer systems extracting approximately 16 percent of the nation's annual groundwater supply (U.S. Geological Survey 2010).

The California Department of Water Resources (DWR) has divided California into 10 hydrologic regions that characterize the large watersheds in the state (Figure 2-1). California's variable topography and hydrologic conditions result in a high degree of variation in the amount of regional precipitation — from 2 inches in Imperial Valley in the south to almost 70 inches near Lake Tahoe in the north. An extensive system of surface water storage and conveyance helps lessen regional water supply shortages and increase supply reliability (Figure 2-2); however, increasing trends toward permanent agricultural cropping hampers California's ability to respond to annual reductions in water supply availability. California's increasing demand for water has led to a greater reliance on groundwater supplies to meet local urban, agricultural, and managed wetlands uses.

Between 2002 and 2010, annual groundwater pumping to meet California's total water use ranged from an estimated 12,019 thousand acre-feet (taf) in 2005 to an estimated 20,093 taf in 2009 (for comparison, this amount is equal to 12 to 20 million acre-feet [maf]), and contributed between 30 and 46 percent toward the state's total water supply. Regionally, annual fluctuations in groundwater extraction can be even more dramatic, as limited surface water supply reliability in some regions of California necessitates large groundwater withdrawals during dry years. In the Tulare Lake Hydrologic Region, for example, the annual volume of groundwater extracted between 2002 and 2010 ranged from 3,504 taf in 2005 to 8,711 taf in 2009, and contributed between 32 and 70 percent toward the region's overall annual water supply between wet and dry years. Conversely, the amount of groundwater extracted from the North Coast Hydrologic Region ranged between 298 taf in 2005 and 398 taf in 2007, and contributed between 31 and 34 percent toward the region's overall annual water supply. The Central Coast is the hydrologic region most reliant upon groundwater, as 83 to 90 percent of the region's water uses were met by groundwater between 2002 and 2010.

Conjunctive management programs and water conservation measures have been developed to make more efficient use of the water stored in California's aquifer systems; however, in several of the high-groundwater-demand regions, groundwater levels and groundwater quality continue to decline, and evidence of renewed land subsidence is more common. It is becoming increasingly evident that more effective groundwater management actions are needed to help balance the demands on groundwater systems to achieve long-term sustainability. In areas where aquifer storage is available and where surface water or recycled water can be recharged, local water management agencies should continue to pursue local and regional subsurface storage programs and establish water budgets to ensure that their groundwater resources are sustainable.

In 1980, Bulletin 118 identified 11 basins subject to critical conditions of overdraft, 31 basins having evidence of adverse impacts of overdraft, and four basins with special problems. Although significant improvements have been made in providing the authority and tools for local groundwater management, 30 years after DWR’s reporting of basins in overdraft, California’s reliance on groundwater continues to increase and the implementation of effective and sustainable groundwater management practices in water-short regions continues to pose major challenges to local resource managers.

One of the more common vehicles for groundwater management is the preparation of groundwater management plans (GWMPs) in accordance with Assembly Bill (AB) 3030, the Groundwater Management Act (1992). The procedural and technical components of AB 3030 are included under Section 10750 et seq. of the California Water Code. The passage of AB 3030 in 1992 encouraged local agencies to prepare and adopt plans for managing their local groundwater resources, even if their groundwater basin exhibited no overdraft conditions. In 2002, the Legislature passed Senate Bill (SB) 1938, which expanded GWMP requirements related to groundwater levels, groundwater quality, inelastic land subsidence, and surface water-groundwater interaction, and required local agencies to develop and adopt plans in order for groundwater projects to be eligible to receive public funds. DWR’s assessment of local groundwater management planning efforts, as discussed later in this chapter, determined that less than 20 percent of the state’s Bulletin 118-defined groundwater basins are covered by a plan that include all of the components required by the California Water Code to qualify as a GWMP.

Despite the recognized challenges associated with local implementation of sustainable groundwater management practices, general consensus among State, regional, and local water resources managers is that local development and implementation of groundwater management, coupled with State financial support and technical guidance, holds the best opportunity for achieving groundwater sustainability. Recent evidence also indicates that improved coordination and inclusion of local GWMP goals and objectives into those of the overlying integrated regional water management (IRWM) plans, or other land use plans, are needed to help advance groundwater sustainability.

Groundwater extraction at rates and volumes that far exceed natural aquifer recharge, or the ability to actively recharge via conjunctive management practices, have resulted in long-term economic benefits for California and have enabled the state to become one of the world’s most productive agricultural regions. These economic benefits, however, have not gone without a broader cost to the quantity and quality of groundwater resources, to the increased energy required to pump groundwater, to the decline in ecosystem services provided by the interaction of groundwater and surface water, and to the infrastructure affected by land subsidence. Existing agricultural and urban developments need to critically evaluate the broader long-term costs and risks associated with unsustainable groundwater pumping. Mitigation against further escalation of groundwater-pumping-related impacts will require stronger and more sustained actions to adjust current land and water resource management practices in high-use areas characterized by unsustainable groundwater-level decline.

Recent programs that help align and prioritize some of the much-needed improvements to California groundwater management include the California Statewide Groundwater Elevation and Monitoring (CASGEM) Program. Prioritization of groundwater basins under the CASGEM Program has determined that 127 of California's 515 groundwater basins account for 96 percent of California's average annual groundwater extraction and 88 percent of the population overlying California's groundwater basins. CASGEM groundwater-basin prioritization results can be used to strategically focus allocation of limited fiscal resources and technical assistance to improve groundwater management practices, data collection, and assessment of basin conditions.

The following statewide groundwater update provides an overview of California's groundwater supply and development, monitoring efforts, aquifer conditions, management activities, data gaps, and groundwater management recommendations. The overall objectives of this statewide groundwater update effort were to improve the quality of groundwater information in *California Water Plan Update 2013* to help State, regional, and local water management groups more accurately evaluate their groundwater resources and implement management strategies that will meet both regional and statewide objectives of effective water resource management and sustainability. More detailed information for each hydrologic region is presented in Chapters 3 through 12 and in the technical appendices.

Statewide Groundwater Supply and Development

This chapter provides a statewide overview of the major aquifer systems that contribute groundwater to the regional water supply, the well infrastructure used to develop these supplies, and an introduction to groundwater basin prioritization for the region.

California's groundwater resources are supplied by both alluvial aquifers and fractured-rock aquifers. Alluvial aquifers are composed of sand and gravel or finer-grained sediments, with groundwater stored within the voids, or pore space, among the alluvial sediments. Fractured-rock aquifers consist of impermeable granitic, metamorphic, volcanic, or hard sedimentary rocks, with groundwater stored within fractures or other void spaces. A general overview of the distribution and extent of California's alluvial and fractured-rock aquifers are provided in the following sections, while more detailed information of the aquifer systems for each hydrologic region can be found in Chapters 3 through 12. Additional aquifer information is provided in DWR's publication, California's Groundwater — Bulletin 118-2003 (http://www.water.ca.gov/groundwater/bulletin118.cfm).

Alluvial Aquifers

California has 515 alluvial groundwater basins and subbasins that encompass almost 62,000 square miles, or 42 percent of the State's geographical area (California Department of Water Resources 2003). In an average water year, Californians extract about 16,500 taf of groundwater, or about 38 percent of the state's total water supply, from alluvial aquifer systems. However, 75 percent of the 515 alluvial basins are considered low-use or very-low-use basins, contributing to only 8 percent of the average annual groundwater supply.

Figure 2-1 California's Hydrologic Regions

Prepared by California Department of Water Resources for California's Groundwater Update 2013

Figure 2-2 **California's Major Rivers and Water Storage/Conveyance Facilities**

The distribution of California's 515 alluvial groundwater basins is shown in Figure 2-3. The alluvial aquifers in these basins are highly variable in their geologic origin, physical and hydrogeological characteristics, horizontal and vertical distribution, production properties, and water quality. California's alluvial aquifers can be grouped into several principal aquifer systems or types of aquifers: the Central Valley aquifer system; the coastal aquifers; the Northern California basin-fill aquifers; and the eastern Sierra Nevada and California Desert aquifers.

Central Valley Aquifer System

The Central Valley aquifer system is located within California's Central Valley and generally includes the valley portion of the Sacramento River, San Joaquin River, and Tulare Lake hydrologic regions. The Central Valley aquifer system is a structural trough covering more than 20,000 square miles extending from north of Red Bluff to south of Bakersfield (U.S. Geological Survey 2005). The valley is bordered to the east by the foothills of the Sierra Nevada and Cascades and to the west by the Coast Ranges. The northern portion of the Central Valley is drained by the Sacramento River, while the middle portion of the valley is drained by the San Joaquin River. Drainage in the Tulare Lake Basin is completely internal, with inflow and runoff removed by infiltration and evapotranspiration.

Major alluvial groundwater basins in the Central Valley consist of the Sacramento Valley and San Joaquin Valley groundwater basins, as well as the aquifers within the Tulare Lake Hydrologic Region. Aquifers in these basins exist under both unconfined and confined conditions.

The Central Valley aquifer systems are comprised primarily of sand, gravel, and clay deposits, approximately 400 miles in length and 20 to 70 miles in width. Although the Central Valley is filled with tens of thousands of feet of unconsolidated sediments, most of the fresh groundwater is found at depths of less than 2,500 feet (U.S. Geological Survey 2005). The aquifer systems in the Sacramento Valley are discussed in Chapter 7, the San Joaquin Valley aquifers are discussed in Chapter 8, and the Tulare Lake area is discussed in Chapter 9.

The Central Valley is the single-most important contributor of agricultural products in the United States, and groundwater for irrigation has been essential in the development of that industry. Approximately 83 percent of California's agricultural groundwater use and 74 percent of California's total groundwater use is extracted from aquifers in the three hydrologic regions (Sacramento River, San Joaquin River, and Tulare Lake) that make up the Central Valley. Groundwater use in the Central Valley varies drastically based on the water year type and the availability of surface water supplies. The 2005-2010 average annual groundwater extraction from the three hydrologic regions in the Central Valley is estimated at 12,126 taf per year, with 10,438 taf per year (86 percent) of the pumped groundwater applied to agricultural uses.

The degree of surface water-groundwater interaction varies throughout the Central Valley aquifer system. In the middle and southern portions of the valley, most of the shallow unconfined aquifer systems remain disconnected from surface water systems throughout the year. Seasonal flow in these local creeks and rivers serve to recharge groundwater systems; however, groundwater levels

Figure 2-3 California Alluvial Groundwater Basins and Subbasins

in most of the unconfined groundwater aquifers never reach as high as local stream channels or contribute to base flow. In some portions of the Sacramento Valley, seasonal precipitation results in the shallow unconfined aquifers reconnecting with the surface water systems. Groundwater discharge into the surface water systems in these areas helps maintain base stream flow and moderate water temperatures. As the seasons progress, groundwater extraction for agricultural and urban uses increases and most of the unconfined aquifer systems along the axis of the valley become disconnected from the surface water bodies. Along the northeastern edges of the valley, some local groundwater systems remain connected throughout the year, contributing toward surface water base flow and cooler water temperatures during fall months. Additional aquifer details are provided in Chapters 7, 8, and 9 of this report.

Coastal Aquifers

The coastal aquifers include a number of basins located adjacent to the Pacific Ocean in the North Coast, San Francisco Bay, Central Coast, and South Coast hydrologic regions. Many of the coastal basins are characterized as structural depressions formed by folding and faulting, and are subsequently filled by marine and alluvial sediments. Groundwater typically occurs under unconfined to confined conditions, with many basins consisting of two or more aquifers separated by fine-grained sediments of variable thickness and extent. Locally, the fine-grained sediments serve as confining layers; however, many of the coastal basins with multiple vertical aquifers are at least partially connected. Seawater intrusion is a common problem in nearly all the coastal aquifers. Additional aquifer details are provided in Chapters 3, 4, 5, and 6 of this report.

Northern California Basin-Fill Aquifers

The most productive and highly utilized aquifers in Northern California are the basin-fill aquifers. These aquifers consist of unconsolidated alluvial sediments. In some basin-fill aquifers, wells drilled into underlying volcanic rocks can produce larger quantities of water than wells completed in the unconsolidated sediments.

Northern California Volcanic-Rock Aquifers

The Northern California volcanic-rock aquifers consist of volcanic rocks that yield water from variable-size fractures and from inter-granular spaces found in porous tuffs. Because water-yielding zones in these rocks are unevenly distributed, wells that yield water are outnumbered by dry holes; however, in some areas, wells completed in the volcanic-rock aquifers yield large volumes of water. The Northern California volcanic-rock aquifers are relatively unexplored and undeveloped.

Eastern Sierra Nevada and California Desert Aquifers

The aquifers underlying the sparsely populated areas east of the Sierra Nevada include alluvial and fractured-rock groundwater basins in the North Lahontan and South Lahontan hydrologic regions, as well as the groundwater basins located the Mojave Desert and Colorado Desert in the Colorado River Hydrologic Region. Additional details of the main aquifers located in these regions are provided in Chapters 10, 11, and 12 of this report.

Fractured-Rock Aquifers

Fractured-rock aquifers are typically found in the mountain and foothill areas adjacent to the alluvial groundwater basins. Because of the highly variable nature of the void spaces within fractured-rock aquifers, wells drawing from fractured-rock aquifers tend to have less capacity and less reliability than wells drawing from alluvial aquifers. On average, wells drawing from fractured-rock aquifers yield less than 10 gallons per minute. Although fractured-rock aquifers are less productive compared with the alluvial aquifers throughout the state, they are commonly the sole source of water and a critically important water supply for many communities.

A statewide characterization of fractured-rock aquifers in California was not developed as part of this Statewide Groundwater Update. Some additional regional details are included in the hydrologic region chapters of this report, and an overview of groundwater in fractured hard rock can be viewed on DWR's Groundwater Information Center (http://www.water.ca.gov/groundwater/index.cfm) in the Groundwater Basics link to Water Fact 1 – Groundwater in Fractured Hard Rock (http://www.dpla.water.ca.gov/sd/groundwater/publications/water_facts_1.pdf).

Well Infrastructure

A key aspect to understanding the state's groundwater supply and development is identifying the age, distribution, and types of wells that have been completed throughout California. A useful source of well information is the well completion reports, or well logs, submitted by licensed well drillers to DWR. Among other things, well logs identify well location, date of completion, and type of well use.

Well drillers have been required by law to submit well logs to the State since 1949. California Water Code Section 13751 requires drillers who construct, alter, abandon, or destroy a well to submit a well log to DWR within 60 days of the completed work. Confidentiality requirements (California Water Code Section 13752) limit access to the well logs solely to governmental agencies making studies, to the owner of a well, and to persons performing environmental cleanup studies.

Well logs submitted to DWR for water supply wells completed from 1977 through 2010 were used to evaluate the distribution and the uses of groundwater wells in California. Despite California Water Code requirements, DWR does not have well logs for all the wells completed throughout the state, and for some well logs, information regarding well location or use is inaccurate, incomplete, ambiguous, or missing. Hence, some well logs could not be used in the evaluation. However, for a general evaluation of well completion and distribution, the quality of the data is considered adequate and informative. Additional information regarding assumptions and methods of reporting well log information to DWR is provided in Appendix A.

The number and distribution of California wells are grouped according to hydrologic region and according to the six most common well use types: domestic, irrigation, public supply, industrial, monitoring, and other. Wells identified as "other" include the less common types of wells, such as stock wells, test wells, or unidentified wells (no information listed on the well log). Table 2-1 lists

Table 2-1 Statewide Number of Well Logs by Hydrologic Region and Well Type (1977-2010)

Hydrologic Region	Total Number of Well Logs by Well Type						Total Well Records
	Domestic	Irrigation	Public Supply	Industrial	Monitoring	Other	
North Coast	24,710	1,899	689	150	6,155	1,352	34,955
San Francisco Bay	8,951	2,594	356	154	41,487	9,399	62,941
Central Coast	17,137	3,849	501	80	4,880	4,480	30,927
South Coast	10,414	4,067	1,029	260	15,935	5,444	37,149
Sacramento River	78,260	6,781	1,628	368	16,514	4,795	108,346
San Joaquin River	47,789	7,280	1,461	225	11,031	5,661	73,447
Tulare Lake	28,466	12,786	1,581	181	3,211	8,097	54,322
North Lahontan	3,064	319	68	40	366	212	4,069
South Lahontan	7,394	521	1,292	196	2,329	1,380	13,112
Colorado River	8,096	1,430	472	85	2,292	826	13,201
Total Well Logs	**234,281**	**41,526**	**9,077**	**1,739**	**104,200**	**41,646**	**432,469**

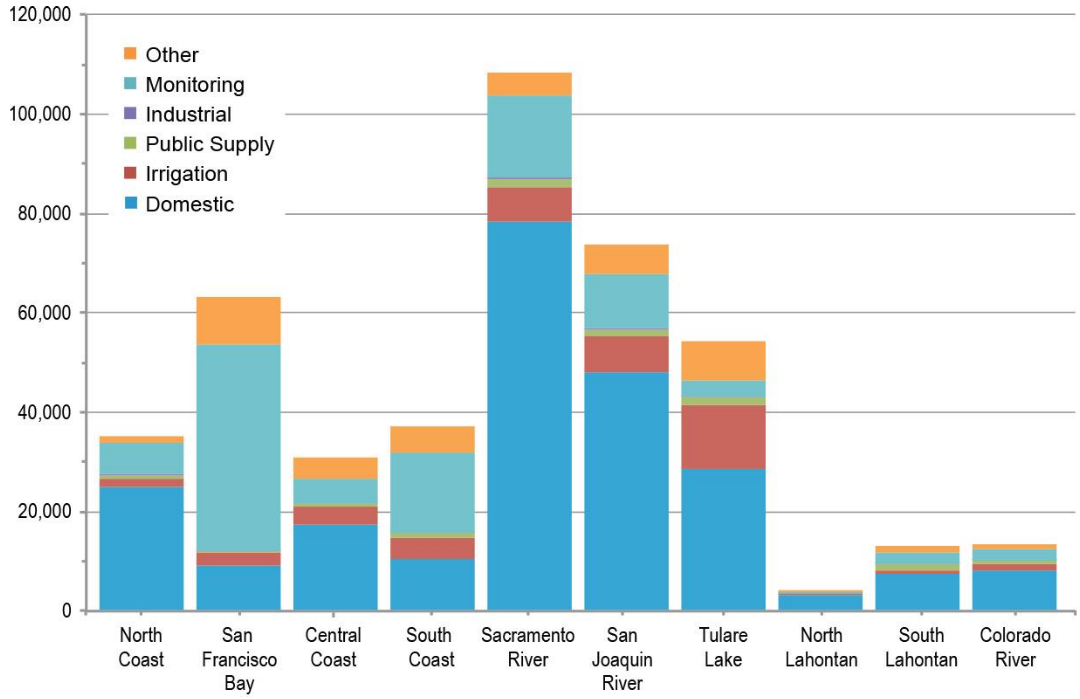
the statewide number of well logs received by the DWR from 1977 to 2010. Figures 2-4 and 2-5 illustrate the well data by use, by hydrologic region and for the state as a whole.

Table 2-1 and Figure 2-4 show that the distribution and number of wells vary widely by hydrologic region and by use. The total number of wells completed in California between 1977 and 2010, based on DWR records, is 432,469 and ranges from a low of 4,069 wells for the North Lahontan Hydrologic Region to a high of 108,346 wells for the Sacramento River Hydrologic Region. The large proportion of wells in Sacramento River Hydrologic Region is related, in part, to size of the region and the abundant number of residences using private domestic wells versus municipal or public supply systems. In the North Lahontan Hydrologic Region, 75 percent are domestic wells.

Figure 2-5 presents the statewide percentage breakdown of wells, by well type, between 1977 and 2010. The figure shows that domestic, irrigation, and monitoring wells account for about 88 percent of all wells in California, with domestic wells accounting for 54 percent, irrigation wells 10 percent, and monitoring wells accounting for 24 percent of the total number of wells. About 10 percent of the wells in the state fall into the “other” category, with public supply and industrial wells collectively accounting for approximately 2 percent of the wells.

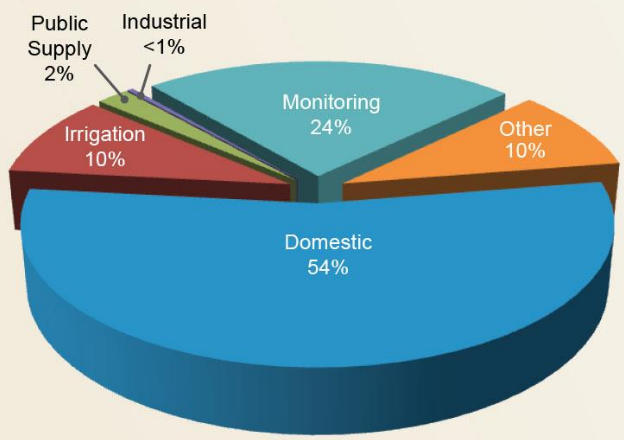
In most parts of the state, domestic wells make up the majority of well logs on file at DWR. For the San Francisco Bay and South Coast hydrologic regions, the number of monitoring wells, especially in the San Francisco Bay Hydrologic Region, exceeds all other types of wells for the 1977-2010 time frame. Monitoring wells comprise 66 and 43 percent, respectively, of the total number of wells for the San Francisco Bay and South Coast hydrologic regions, which is much higher than the statewide average of 24 percent. The higher number of monitoring wells in these regions is likely because of the groundwater quality monitoring associated with site characterization and clean-up efforts at leaky underground storage tank locations, as well as the limited number of irrigation and private domestic wells.

Figure 2-4 Statewide Number of Well Logs by Hydrologic Region and Well Type (1977-2010)



Prepared by California Department of Water Resources for California's Groundwater Update 2013

Figure 2-5 Statewide Percentages of Well Logs by Type of Use (1977-2010)



Statewide Well Logs Summary by Well Type

Well Type	Number of Well Logs
Domestic	234,281
Irrigation	41,526
Public Supply	9,077
Industrial	1,739
Monitoring	104,200
Other	41,646
Total	**432,469**

Prepared by California Department of Water Resources for California's Groundwater Update 2013

The number of irrigation wells (12,786) in the Tulare Lake Hydrologic Region is almost twice that of the adjacent San Joaquin River Hydrologic Region. Irrigation wells for the Tulare Lake Hydrologic Region average about 24 percent of the total number of wells, which is more than twice the statewide average of 10 percent. Irrigation wells installed between 1977 and 2010 in the San Joaquin River and Sacramento River hydrologic regions, which have the second and third highest number of irrigation wells, numbered 7,280 and 6,781, respectively. Large numbers of irrigation wells are typically indicative of high groundwater use regions, as irrigation wells are generally much higher-capacity wells than domestic wells.

In addition to analyzing the number of wells by location and use, well logs were analyzed by well installation date (Figure 2-6). Evaluating the number and types of wells completed over time can help offer a perspective on the average age of the existing well infrastructure and the general pattern of wells installed during various hydrologic and economic cycles.

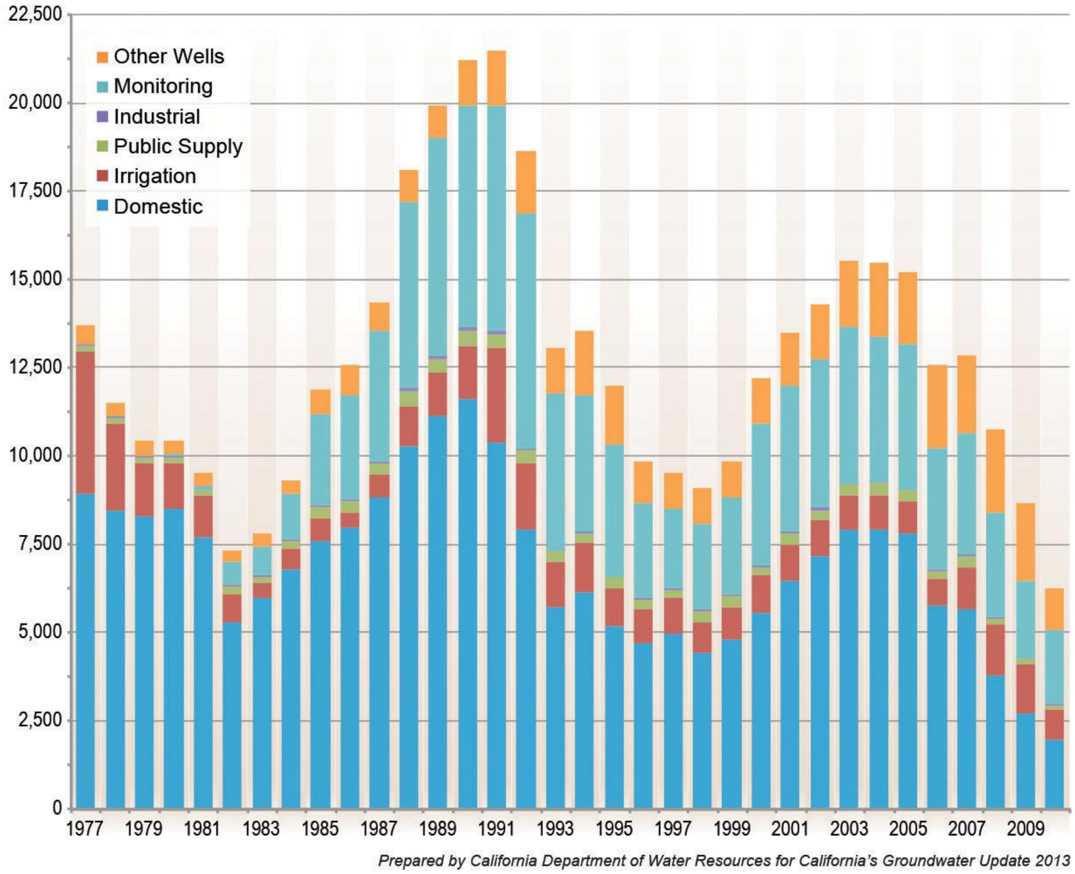
Figure 2-6 shows a cyclic pattern of well installation. Multiple factors are known to affect the annual number and type of wells drilled – some of these factors include the annual variations in climate, economy, agricultural cropping trends, or alternative water supply availability. New well construction between 1977 and 2010 ranged from a low of 6,250 wells in 2010 to a high of 21,496 wells in 1991, with an average of 12,720 wells per year. It should be noted, however, that the low number of wells reported for 2009 and 2010 most likely reflects a lag in well log submissions by well drillers, as well as DWR's well log processing efforts, but could also be a reflection of economic downturn.

Installation trends for irrigation wells tend to more closely follow changes in annual weather conditions, cropping trends, and availability of surface water supplies for agricultural use. Irrigation well installation peaked at 4,035 wells per year following the 1976-1977 drought, and continued at an installation rate of approximately 1,444 wells per year through early 1980s. Irrigation well installation dropped to an average of 547 wells per year during the wet years of the mid-1980s before increasing again to an average of 1,654 wells per year during the 1989-1994 drought period. Between 1995 and 2010, the average number of irrigation wells drilled in California was 1,030.

The DWR well log database does not differentiate between new irrigation wells installed and the deepening of existing wells. Therefore, a portion of irrigation well logs are likely related to the deepening of existing irrigation wells. Much of the irrigation well infrastructure installed during the late 1970s and early 1980s is still in use today.

Similar to irrigation well installation, domestic well construction also responds to changes in climatic conditions. Variations in domestic well drilling activity can also be attributed to the economy and the resulting fluctuations in residential housing construction. Installation of domestic wells averaged 6,891 wells per year between 1977 and 2010, with a peak of 11,604 wells in 1990 and a low of 1,957 wells in 2010. The 2008 to 2010 decline in domestic well drilling is likely because of the economic downturn and related drop in housing construction. However, a portion of the lower number of well logs recorded for 2010 could also have resulted from delays in receiving and processing well drillers logs. As with irrigation wells, a portion of

Figure 2-6 Statewide Number of Well Logs Filed per Year, by Well Type (1977-2010)



the new well logs submitted for domestic wells may involve the deepening of existing domestic wells because of declining groundwater levels in the area.

Monitoring wells were first recorded in significant numbers in 1984, with slightly more than 1,300 wells installed. The sudden spike in monitoring well installation corresponds to the introduction of the State of California Underground Storage Tank Program in 1984. The program provided partial reimbursement of expenses associated with the cleanup of leaking underground storage tanks and quickly resulted in an increase in the installation of groundwater quality monitoring wells. Beginning in 1987, changes in California Water Code Section 13751 required well drillers to begin submitting well logs for monitoring well completions. Well logs typically do not distinguish between monitoring wells installed as part of a groundwater clean-up project versus those installed primarily to collect changes in groundwater levels. However, information on the well logs supports a conclusion that the majority of the monitoring wells are completed for use in environmental assessments related to leaking underground storage tanks, waste disposal sites, and hazardous chemical spills. Since 1984, monitoring well installation in California has averaged approximately 3,800 wells per year, with a peak of 6,675 wells in 1992.

The installation of public supply and industrial wells in California remained fairly constant during the 1977-2010 time frame. The average number of public supply wells drilled throughout

California is 267 wells per year, with a low of 126 wells in 2010 and a high of 439 wells in 1990. The average number of industrial wells drilled between 1977 and 2010 is 51 wells per year.

CASGEM Basin Prioritization

As part of the California 2009 Comprehensive Water Package legislation (SB X7-6), DWR implemented the California Statewide Groundwater Elevation Monitoring (CASGEM) Program. The SB X7-6 Groundwater Monitoring legislation added Part 2.11 to Division 6 of the California Water Code (Section 10920 et seq.), which established provisions and requirements for local agencies to develop and conduct groundwater level monitoring programs. The legislation required DWR to identify the extent of groundwater elevation monitoring within each of the alluvial groundwater basins defined in Bulletin 118-2003 and to prioritize those basins to help identify, evaluate, and determine the need for additional groundwater level monitoring. The legislation directed DWR to consider, to the extent available, all of the following data components to prioritize the basins.

1. The population overlying the basin.
2. The rate of current and projected growth of the population overlying the basin.
3. The number of public supply wells that draw from the basin.
4. The total number of wells that draw from the basin.
5. The irrigated acreage overlying the basin.
6. The degree to which persons overlying the basin rely on groundwater as their primary source of water.
7. Any documented impacts on the groundwater within the basin, including overdraft, subsidence, saline intrusion, and other water quality degradation.
8. Any other information determined to be relevant by the department.

Using groundwater reliance as the leading indicator of basin priority, DWR evaluated California’s 515 groundwater basins identified in Bulletin 118-2003 and categorized them into four prioritization groups: high, medium, low, and very low priority.

The June 2014 CASGEM basin prioritization for California’s 515 groundwater basins is summarized in Table 2-2 and shown in Figure 2-7. Results for all of the final CASGEM groundwater basin prioritization is provided in Appendix B. The CASGEM basin prioritization identifies 43 groundwater basins as high priority, 84 basins as medium priority, 27 basins as low priority, and the remaining 361 groundwater basins or subbasins as very low priority. The 127 groundwater basins designated as high or medium priority include 96 percent of the annual groundwater use and 88 percent of the 2010 population overlying the groundwater basin area.

Although the primary intent of basin prioritization is to assist DWR in implementing the CASGEM Program, based on the comprehensive set of data, the basin prioritization effort is also a valuable statewide tool to help evaluate, focus, and align limited resources to implement effective groundwater management practices and to improve the statewide reliability and sustainability of groundwater resources. To obtain the highest return on investment statewide, implementation of sustainable groundwater resource management should first focus on the 127 high- and medium-priority basins shown in Figure 2-7 and listed in Appendix B.

Table 2-2 CASGEM Prioritization for California Groundwater Basins

Basin Ranking	Basin Count	Percent of Total	
		Groundwater Use	Population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Total	**515**	**100%**	**100%**
Population of Groundwater Basin Area			**29,878,103[a]**

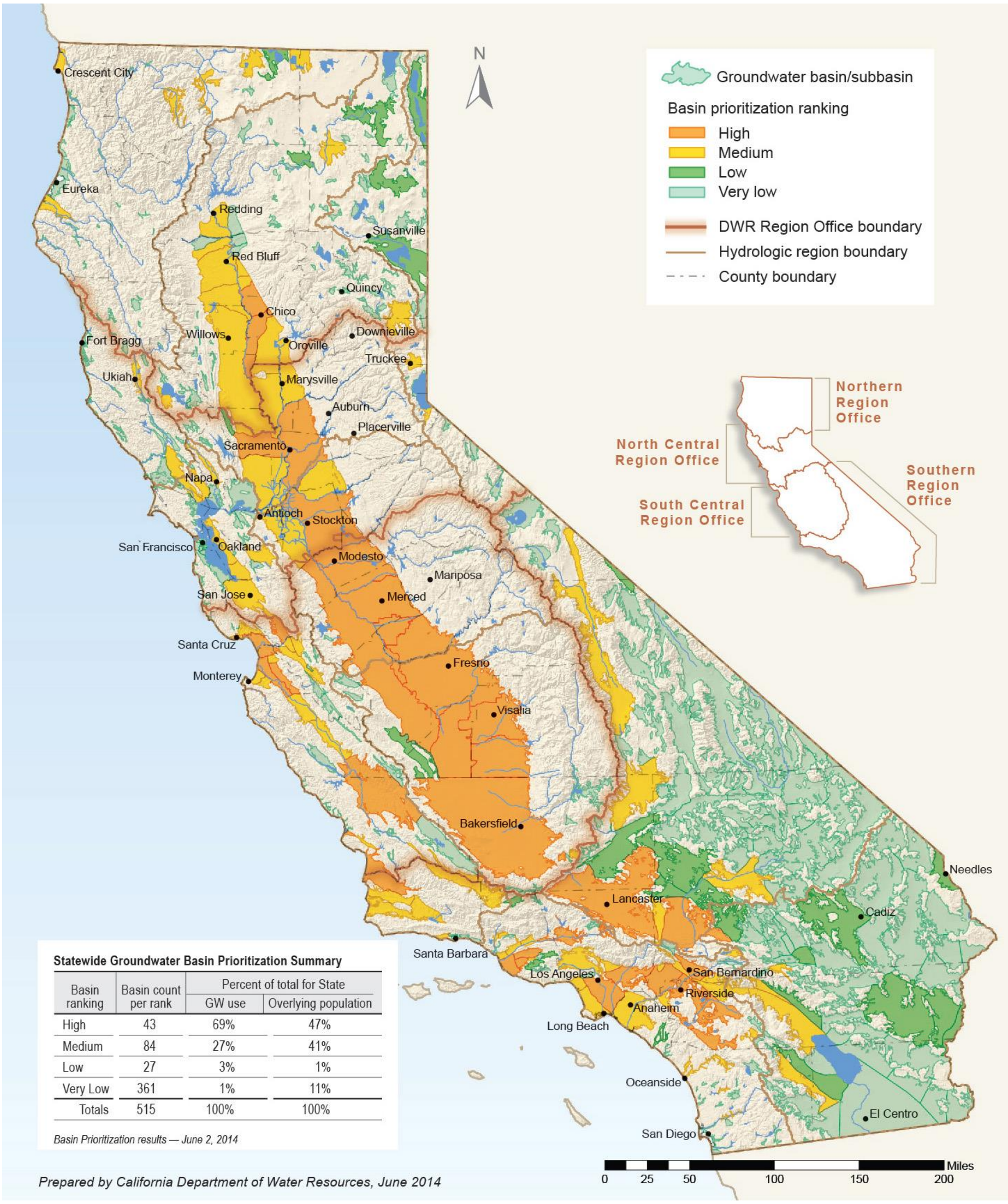
Notes:
[a]Includes the population within all 515 basins.
Ranking as of June 2014.
Senate Bill X7-6 (SB X7-6; Part 2.11 to Division 6 of the California Water Code Section 10920 et seq.) requires, as part of the CASGEM program, DWR to prioritize groundwater basins to help identify, evaluate, and determine the need for additional groundwater level monitoring by considering available data that include the population overlying the basin, the rate of current and projected growth of the population overlying the basin, the number of public supply wells that draw from the basin, the total number of wells that draw from the basin, the irrigated acreage overlying the basin, the degree to which persons overlying the basin rely on groundwater as their primary source of water, any documented impacts on the groundwater within the basin, including overdraft, subsidence, saline intrusion, and other water quality degradation, and any other information determined to be relevant by the DWR."
Using groundwater reliance as the leading indicator of basin priority, DWR evaluated California's 515 alluvial groundwater basins and categorized them into four groups - high, medium, low, and very low.

Statewide Groundwater Use

The amount and timing of groundwater extraction, along with the location of extraction and type of groundwater use, are fundamental components for developing a groundwater basin budget and identifying effective options for groundwater management. While some types of groundwater uses are reported for some California basins, the majority of groundwater users are not required to monitor, meter, or record their annual groundwater extraction amounts. Groundwater use estimates for this report are based on water supply and balance information derived from DWR land use surveys and from groundwater use information voluntarily provided to DWR by water purveyors or other State agencies.

Groundwater extraction estimates derived from land and water use methods typically assume that local surface-water supplies are used first to meet local water demands. Once surface water supplies have been fully allocated, if crop demand and water balance information indicates that additional water supplies are needed, groundwater supplies are then applied until the full water use is met and the overall supply and use for the area is balanced. For agricultural areas utilizing conjunctive management practices, which may involve optimally using surface water and groundwater supplies, accurate estimates of annual groundwater extraction using the land and water use method can be challenging.

Figure 2-7 CASGEM Groundwater Basin Prioritization Map



Statewide Groundwater Basin Prioritization Summary

Basin ranking	Basin count per rank	Percent of total for State: GW use	Percent of total for State: Overlying population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals	515	100%	100%

Basin Prioritization results — June 2, 2014

DWR water supply and balance data are aggregated by hydrologic regions, which generally correspond to watershed boundaries. The land and water use data is first compiled and analyzed by detailed analysis units (DAUs). Water supply and balance data for DAUs are then compiled into larger planning areas (PA) and then into hydrologic regions, and finally into a statewide water supply and balance estimate. To assist local resource planning, DWR also generates water supply and balance information by county. Although some local groundwater management groups independently develop groundwater extraction estimates for their groundwater basins, DWR does not currently generate groundwater extraction information by groundwater basin area.

Water use is reported by water year (October 1 through September 30) and categorized according to urban, agriculture, and managed wetlands uses. Reference to *total water supply* for a region represents the sum of surface water, groundwater, and reused/recycled water supplies. Reused/recycled water supplies also include desalinated water supplies. Statewide reporting of groundwater supply information is presented by hydrologic region and by type of use. Further breakdown of groundwater supply by PA and county is provided under the various hydrologic region reports in Chapters 3 through 12, and in Appendix C. Information on water use analysis is provided in Appendix A.

2005-2010 Average Annual Groundwater Supply

Table 2-3 lists the 2005-2010 average annual total water supply met by groundwater, by hydrologic region, and by type of use. Between 2005 and 2010, statewide precipitation averaged 96 percent of the 30-year average precipitation. However, dry conditions and substantial regulatory cutback of imported surface water between 2007 and 2009 significantly increased groundwater pumping for agricultural use. Groundwater use in Table 2-3 is reported in units of thousand acre-feet and by the percentage that groundwater contributes to the total water supply for each of California's 10 hydrologic regions. Table 2-4 identifies the percentage breakdown of California's average annual groundwater supply, by hydrologic region and by type of use. Figure 2-8 illustrates the 2005-2010 average annual groundwater supply relative to other water supply sources, and the percentage of the total water supply in each hydrologic region met by groundwater.

As shown in Table 2-3, the average annual volume of groundwater extracted from California's aquifers, between 2005 and 2010, was 16,461 taf and contributed 38 percent of the state's total water supply. Evaluation of the statewide groundwater supply, by type of use, indicates that groundwater supplies contributed 39 percent of the average annual agricultural water use, 41 percent of the total urban water use, and 18 percent of the state's managed wetlands water use.

Evaluation of groundwater extraction by hydrologic region and type of use (Table 2-3) indicates that the three regions located in the Central Valley (Tulare Lake, San Joaquin River, and Sacramento River) collectively account for 74 percent of California's average annual groundwater extraction, based on 2005-2010 data. Groundwater extraction in the Tulare Lake Hydrologic Region averages 6,185 taf per year, which is almost double that of the next largest regional groundwater user (San Joaquin River Hydrologic Region). Not only is the Tulare Lake

Table 2-3 Average Annual Groundwater Supply and Percentage of Total Supply Met by Groundwater, by Hydrologic Region and Type of Use (2005-2010)

Hydrologic Region	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groundwater	
	taf	%[a]	taf	%[a]	taf	%[a]	taf	%[a]
North Coast	301.3	41%	60.3	41%	2.5	1%	364.0	32%
San Francisco	76.1	74%	183.5	16%	0.0	0%	259.5	21%
Central Coast	906.1	91%	213.3	71%	0.0	0%	1,119.5	86%
South Coast	385.4	54%	1,219.6	31%	0.0	0%	1,605.0	34%
Sacramento River	2,294.2	30%	428.6	47%	20.1	4%	2,742.9	30%
San Joaquin	2,591.8	36%	415.9	58%	190.7	38%	3,198.4	38%
Tulare Lake	5,551.8	51%	604.0	82%	28.9	37%	6,184.8	53%
North Lahontan	118.4	27%	37.1	84%	10.7	48%	166.2	32%
South Lahontan	270.6	72%	170.3	58%	0.0	0%	440.9	66%
Colorado River	50.1	1%	329.7	53%	0.0	0%	379.7	9%
2005-2010 Annual Average California Total	**12,545.7**	**39%**	**3,662.2**	**41%**	**252.9**	**18%**	**16,460.8**	**38%**

Notes:
taf = thousand acre-feet, Total water use = groundwater + surface water + reuse.
[a]Percent use is the percentage of the total water supply that is met by groundwater, by type of use.
2005-2010 precipitation equals 96 percent of the 30-year average for California.

Hydrologic Region the largest groundwater user, but it is also the third most groundwater-reliant region in California, with groundwater contributing 53 percent of the region's total water supply. Annual groundwater use in the San Joaquin River Hydrologic Region, between 2005 and 2010, averaged 3,198 taf per year and met 38 percent of the region's total water use. In the Sacramento River Hydrologic Region, an average of 2,743 taf of groundwater per year is extracted to meet 30 percent of the region's total water use.

The South Coast Hydrologic Region is the fourth largest groundwater user, extracting an estimated 1,605 taf of groundwater per year, or 10 percent of the 2005-2010 average annual statewide groundwater extraction. Because of available surface water supplies and extensive use of recycled water, the South Coast region relies on groundwater to meet 34 percent of its total water use.

The two most groundwater-reliant regions in California are the Central Coast and South Lahontan hydrologic regions, where 86 percent and 66 percent, respectively, of the total water use are met by groundwater. Volumetrically, these two regions combined account for only 10 percent of the 2005-2010 average annual statewide groundwater extraction.

Table 2-4 shows a percentage breakdown of the total agricultural, urban, and managed wetlands water uses in California, by hydrologic region and by statewide total, met by

Table 2-4 Percent of California's Statewide Average Annual Groundwater Supply by Hydrologic Region and by Type of Use (2005-2010)

Hydrologic Region	Agriculture Use of Groundwater	Urban Use of Groundwater	Managed Wetlands Use of Groundwater	Groundwater Use by HR
	%[a]	%[a]	%[a]	%[b]
North Coast	83%	16%	1%	2%
San Francisco	29%	71%	0%	2%
Central Coast	81%	19%	0%	7%
South Coast	24%	76%	0%	10%
Sacramento River	84%	16%	1%	17%
San Joaquin	81%	13%	6%	19%
Tulare Lake	90%	10%	<1%	38%
North Lahontan	71%	22%	6%	1%
South Lahontan	61%	39%	0%	3%
Colorado River	13%	87%	0%	2%
2005-2010 Annual Average California Total	**76%**	**22%**	**2%**	**100%**

Notes:
HR = hydrologic region
[a]Percent use is average annual groundwater use by hydrologic region and type of use, compared to the total groundwater use for the hydrologic region.
[b]Percent of California total groundwater use.

groundwater. While 38 percent of California's 2005-2010 average annual total water supplies are met by groundwater, 76 percent of the groundwater extracted on an average annual basis is applied to meet agricultural use, 22 percent is applied to meet urban use, and 2 percent is applied to meet managed wetlands use.

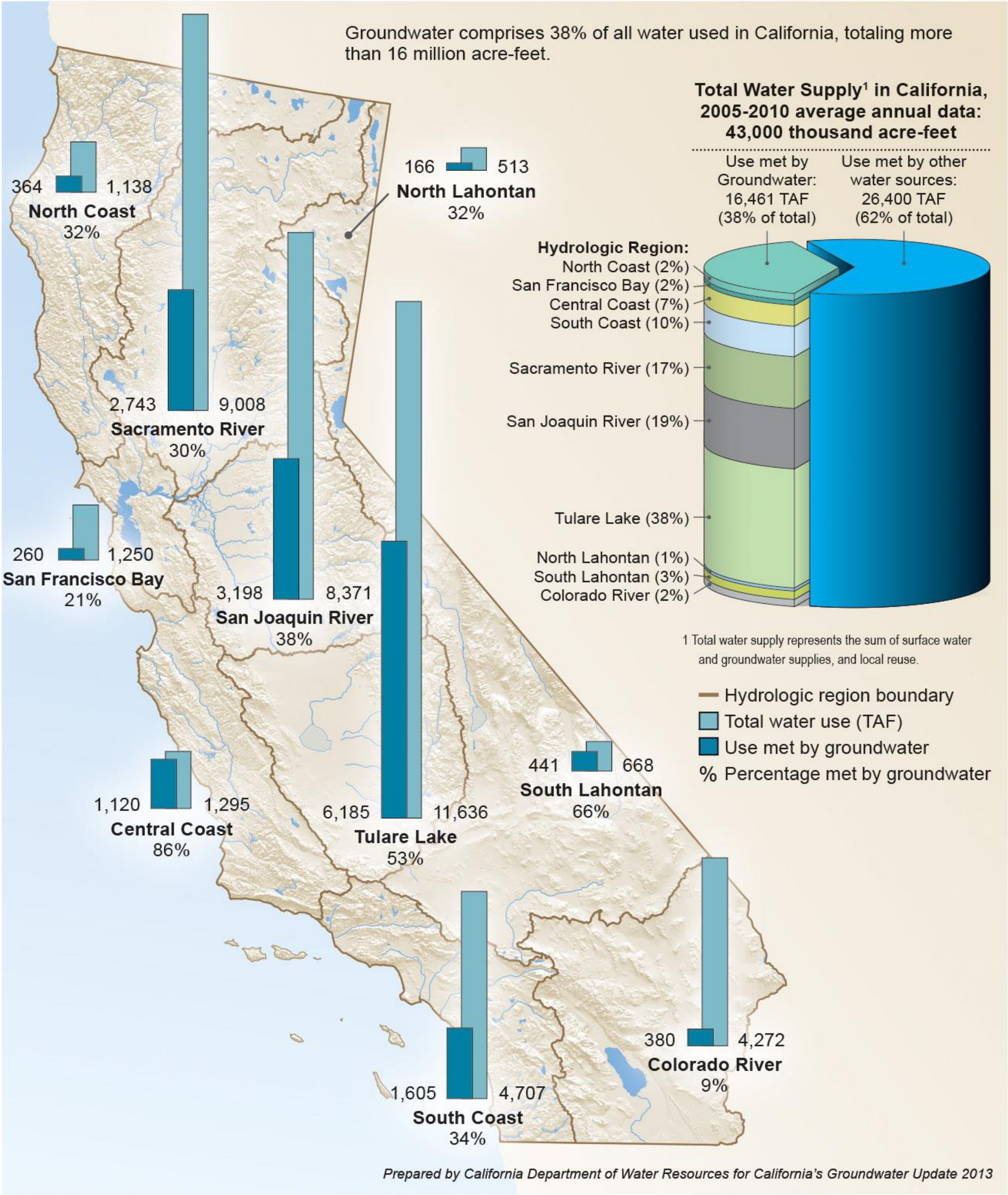
Change in Annual Groundwater Supply

California's variable topography and hydrologic conditions results in a high-degree of variation in the amount of regional precipitation — from 2 inches in the Imperial Valley in the south to almost 70 inches near Lake Tahoe in the north. California's extensive system of surface water storage and conveyance infrastructure helps lessen regional water supply shortages and increase supply reliability; however, increasing trends toward permanent agricultural cropping hampers California's ability to respond and adapt to progressively reduced water supply availability.

California's increasing demand for water has led to a greater reliance on groundwater supplies to meet local urban, agricultural, and managed wetlands uses, and has resulted in large fluctuations in the annual amount of groundwater extraction.

Figures 2-9 and 2-10 illustrate California's water supply trends between 2002 and 2010. The right side of Figure 2-9 illustrates the total statewide water supply volume by supply type (groundwater, surface water, and reused/recycled water), while the left side shows the percentage of the overall water supply that is met by groundwater relative to surface water and

Figure 2-8 California's Statewide Water Supply and Percent Total Supply Met by Groundwater, by Hydrologic Region (2005-2010)



reuse/recycled water. The center column identifies the water year along with the corresponding amount of precipitation, as a percentage of the previous 30-year statewide average.

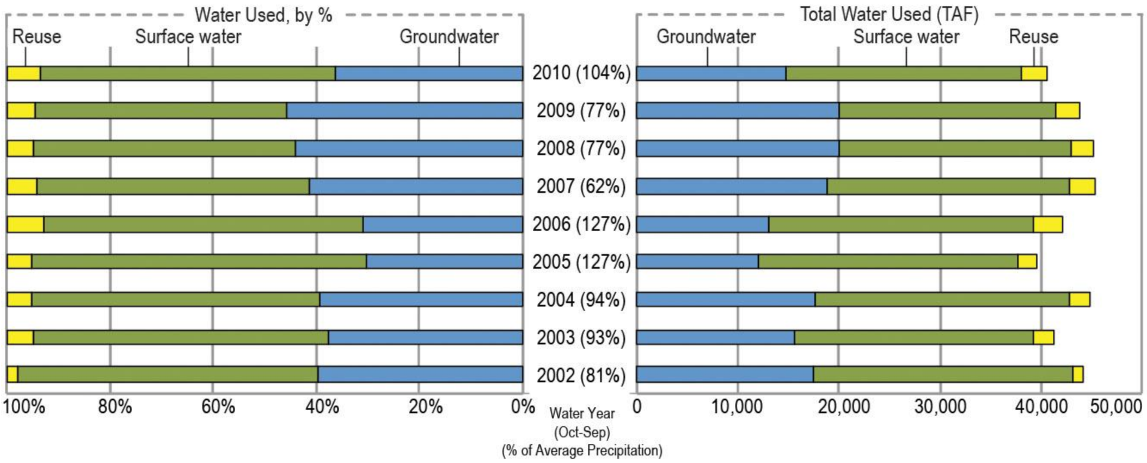
Between 2002 and 2010, the total water supply to meet statewide agricultural, urban, and managed wetlands uses ranged from a low of 39,654 taf in 2005 to a high of 45,459 taf in 2007; the average total water supply in California during this period was 43,063 taf. The difference between the highest and lowest statewide total water supply between 2002 and 2010 was equal to approximately 13 percent of the average total supply. Statewide surface water supplies ranged between a low of 21,393 taf in 2009 and a high of 26,101 taf in 2006, with a fluctuation of about 19 percent of the annual average of 24,216 taf. The estimated amount of groundwater extracted from California's aquifers during this nine-year period ranged between 12,019 taf in 2005 and 20,093 taf in 2009, with a fluctuation of about 48 percent of the annual average of 16,613 taf. Water supply attributed to reused or recycled water sources fluctuated between 967 taf in 2002 and 2,932 taf in 2006 and averaged 2,233 taf per year. Disregarding reused or recycled water supply (a much smaller overall quantity), the large fluctuation in groundwater supply (48 percent) relative to the fluctuation in surface water supply (19 percent) indicates a much higher variability in groundwater supply versus surface water supply to meet annual water use.

Figure 2-9 illustrates the concept of conjunctive management of water supplies by indicating increased use of groundwater during years of decreased surface water supply availability. Thus, years of reduced surface water availability, due in part to reduced precipitation amounts, correspond to years of increased groundwater pumping, while years of peak surface water availability typically correspond to years of reduced groundwater pumping. The percentage of total water supply met by surface water fluctuated between 49 and 65 percent while the total water supply met by groundwater fluctuated between 30 and 46 percent.

Figure 2-10 shows the 2002-2010 annual percentage and volume of groundwater supply extracted to meet urban, agricultural, and managed wetlands uses in California. The right side of Figure 2-10 illustrates the annual volume of groundwater extraction by type of use, while the left side shows the percentage of groundwater extraction by type of use. Figure 2-10 also illustrates how, depending on the water year, small changes in the percentage can result in large volumetric changes to groundwater extraction. For example, between 2005 and 2009, the contribution from groundwater to meet agricultural water use increased from 69 to 80 percent. The increase in groundwater extraction to meet agricultural water use during this time required almost double the volume of groundwater pumped. In 2005, an estimated 8,260 taf of groundwater was pumped for agricultural use, compared with 16,083 taf in 2009.

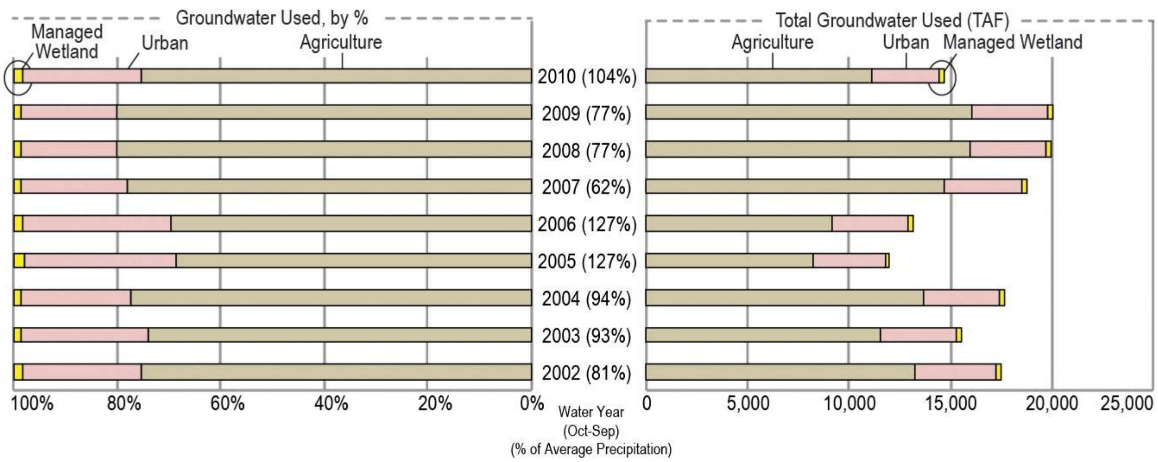
The statewide amount of groundwater to meet urban use, between 2002 and 2010, ranged from a low of 3,368 taf in 2010 to a high of 3,983 taf in 2002, and accounted for 19 to 29 percent of the total groundwater supply. Compared with agricultural and urban uses, the application of groundwater supplies for managed wetlands use is fairly minor. The use of groundwater on an annual basis for managed wetlands programs ranged between 208 taf and 306 taf, and equaled 1 to 2 percent of the average annual groundwater extraction.

Figure 2-9 California's Annual Surface Water and Groundwater Supply Trend (2002-2010)



Prepared by California Department of Water Resources for California's Groundwater Update 2013

Figure 2-10 California's Annual Groundwater Supply Trend by Type of Use (2002-2010)



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Statewide Groundwater Monitoring Efforts

Groundwater resource monitoring and evaluation is essential to understanding groundwater conditions, identifying effective resource management strategies, and implementing sustainable resource management practices. California Water Code Section 10753.7 requires local agencies seeking State funds administered by DWR to prepare and implement GWMPs that include monitoring of groundwater levels, groundwater quality degradation, inelastic land subsidence, and changes in surface water flow and quality that directly affect groundwater levels or quality. The protocols associated with groundwater monitoring can vary greatly depending on local conditions; but overall, monitoring protocols should be designed to generate information that promotes efficient and effective groundwater management.

This section summarizes some of the statewide groundwater level, groundwater quality, and land subsidence monitoring activities. The summary includes publically available groundwater data compiled by DWR, the State Water Resources Control Board (SWRCB) and the regional water quality control boards (RWQCBs), California Department of Public Health (CDPH), U.S. Bureau of Reclamation (USBR), and the U.S. Geological Survey (USGS). Information regarding the groundwater monitoring methods, assumptions, and data availability is provided in Appendix A.

Groundwater Level Monitoring

State and federal agencies with groundwater level monitoring programs in California include DWR, USGS, and USBR. Groundwater level monitoring is also performed by CASGEM-designated monitoring entities, as well as local cooperators that measure, or contract others to measure, groundwater levels. Groundwater level information presented in this section is publically available through DWR or USGS online information systems. Privately collected and locally maintained groundwater level data are not included in this analysis. In addition, groundwater level information represents only active monitoring wells, or those wells that have been measured since January 1, 2010, and monitoring groups that have entered data into the CASGEM or USGS online databases as of July 2012. Because monitoring programs are frequently adjusted to meet changing demands and management actions, the statewide groundwater level monitoring information may not represent the most current information available. Updated groundwater level information may be obtained online from the DWR CASGEM Program (http://www.water.ca.gov/groundwater/casgem/) and through the USGS National Water Information System (http://maps.waterdata.usgs.gov/mapper/index.html).

The location of groundwater level monitoring wells with publically available data is presented in Figure 2-11 and Figure 2-12, by monitoring entity and by the type of well. Figures 2-11 and 2-12 also include inset tables listing the associated number of monitoring wells by entity and by well type. Additional information regarding the individual monitoring entities is provided by hydrologic region in Chapters 3 through 12 of this report.

Figure 2-11 shows that, as of July 2012, a total of 10,834 wells were being actively monitored for groundwater levels. The DWR monitoring network consists of 1,298 wells covering 78 Bulletin 118-2003 defined groundwater basins, 17 non-alluvial basins, and six hydrologic regions. Approximately half of the wells monitored by DWR are located within the Sacramento River Hydrologic Region. The USBR monitoring network consists of 481 wells covering eight groundwater basins, 68 non-alluvial basins, and the three hydrologic regions located in the Central Valley. Approximately 227 of the wells monitored by USBR are within the San Joaquin River Hydrologic Region. The USGS monitors an estimated 1,909 wells for groundwater level information, covering 83 groundwater basins, 33 non-alluvial basins, and all 10 hydrologic regions. More than 95 percent of the USGS groundwater level monitoring takes place outside the Central Valley, with the majority of wells located within the South Lahontan and Central Coast hydrologic regions. Monitoring cooperators measure groundwater levels in 2,551 wells in 51 groundwater basins, six non-alluvial basins, and within nine of the state’s hydrologic regions; almost 30 percent of the monitoring cooperators are within the San Joaquin River Hydrologic Region. DWR-designated CASGEM monitoring entities collect groundwater level data in 4,595 wells, covering 112 groundwater basins, two non-alluvial basins, and in nine hydrologic regions. About 40 percent of the CASGEM monitoring entity wells are located within the boundaries of the Tulare Lake Hydrologic Region, while the South Coast and South Lahontan hydrologic regions include about 17 and 16 percent of the wells, respectively.

The groundwater level monitoring wells are also categorized by the type of well use, which includes irrigation, domestic, observation, public supply, and “other” types of wells. Groundwater level monitoring wells identified as “other” include a combination of the less common well types, such as stock wells, test wells, industrial wells, or unidentified wells (no information listed on the well log). Wells listed as “observation” also include those wells described by drillers in the well logs as “monitoring” wells. Some of the domestic and irrigation wells used for groundwater level monitoring include actively operated wells, as well as older inactive or unused wells.

Figure 2-12 shows that 51 percent of the 10,834 monitoring wells having publically available groundwater level data have a use classified as “other.” Irrigation wells comprise 24 percent of the groundwater level monitoring wells and observation wells comprise 16 percent of the wells. Some observation wells are constructed as a nested or clustered set of dedicated monitoring wells, designed to characterize groundwater conditions across specific depth intervals in the aquifer system. Domestic wells and public supply wells each represent 5 percent of the reported wells statewide.

Based on CASGEM basin prioritization as of June 2014, 127 high- and medium-priority groundwater basins were identified in California. A list of the high- and medium-priority basins, along with a breakdown of the number of groundwater level monitoring wells, is provided by hydrologic region in Chapters 3 through 12 of this report. As of December 2013, approximately 65 percent of California’s high-priority basins and 64 percent of the medium-priority basins were being partially or fully monitored in accordance with the requirements of the CASGEM Program. However, 45 high- and medium-priority basins, or approximately 35 percent of the basins, are currently not being monitored under the CASGEM Program.

Groundwater Quality Monitoring

Groundwater quality monitoring is an important aspect of effective groundwater basin management and is one of the required groundwater management planning components under California Water Code Section 10753.7. Groundwater quality monitoring and assessment evaluates current conditions, can be used to establish groundwater quality thresholds, and can help guide management decisions. Without sufficient groundwater quality monitoring it is almost impossible to determine if groundwater problems exist, or to forecast the potential for future problems that may warrant management actions. Many local, regional, and State agencies have statutory responsibility or authority to collect water quality and water use/level data and information; however, monitoring is inconsistent throughout the state, with significant regional variation in parameters monitored, monitoring frequency, and data availability. In spite of these inconsistencies, there are excellent examples of groundwater monitoring programs being implemented at the local, regional, and State levels. A number of the existing groundwater quality monitoring activities were initiated as part of the Groundwater Quality Monitoring Act of 2001, which implemented goals to improve and increase the statewide availability of groundwater quality data. A comprehensive presentation of statewide groundwater-quality monitoring activities is beyond the scope of this report; however, a summary of the regional groundwater quality monitoring activities and information specific to each hydrologic region is provided in Chapters 3 through 12 of this report.

Figure 2-11 California Groundwater Level Monitoring Wells by Monitoring Entity

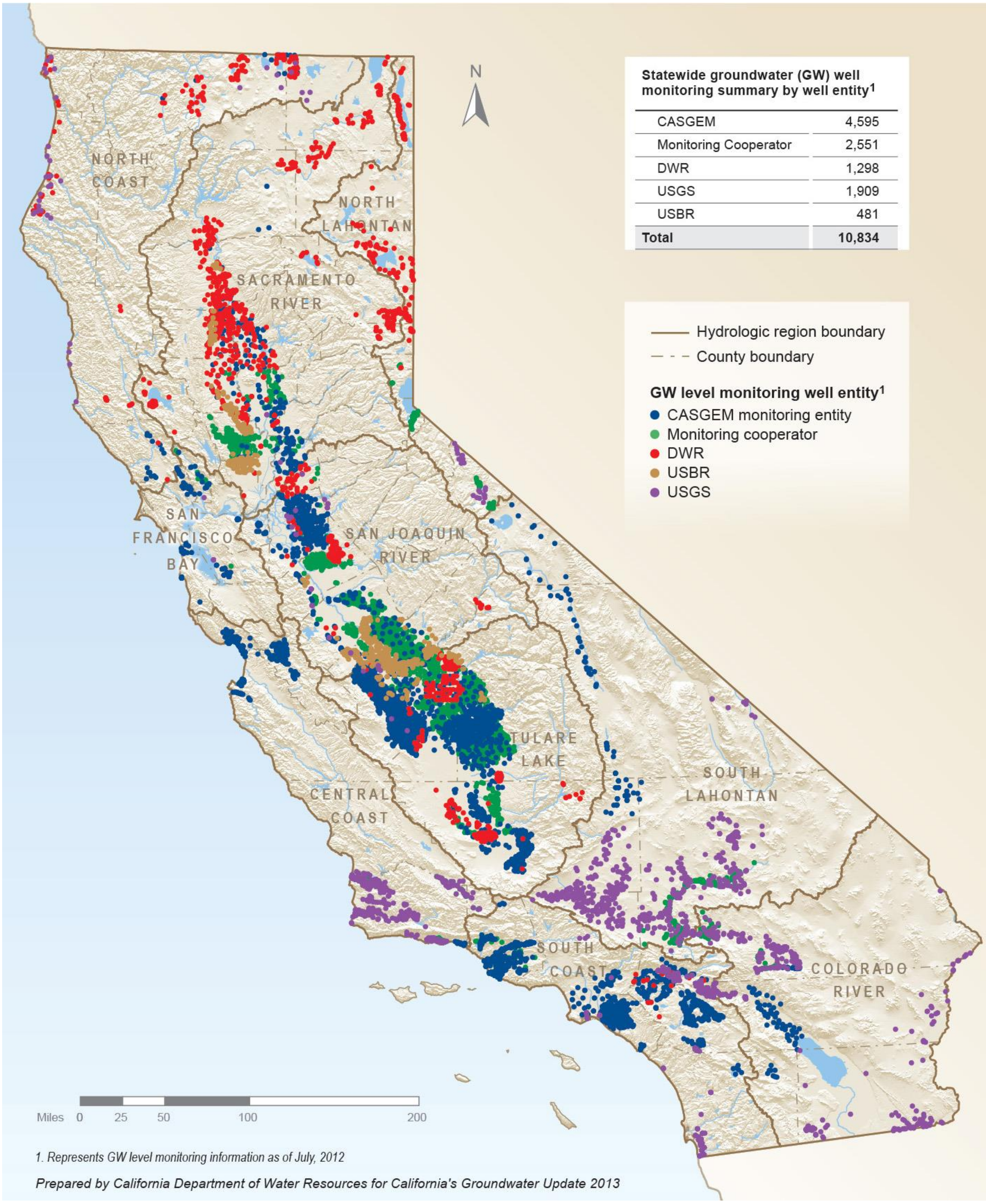
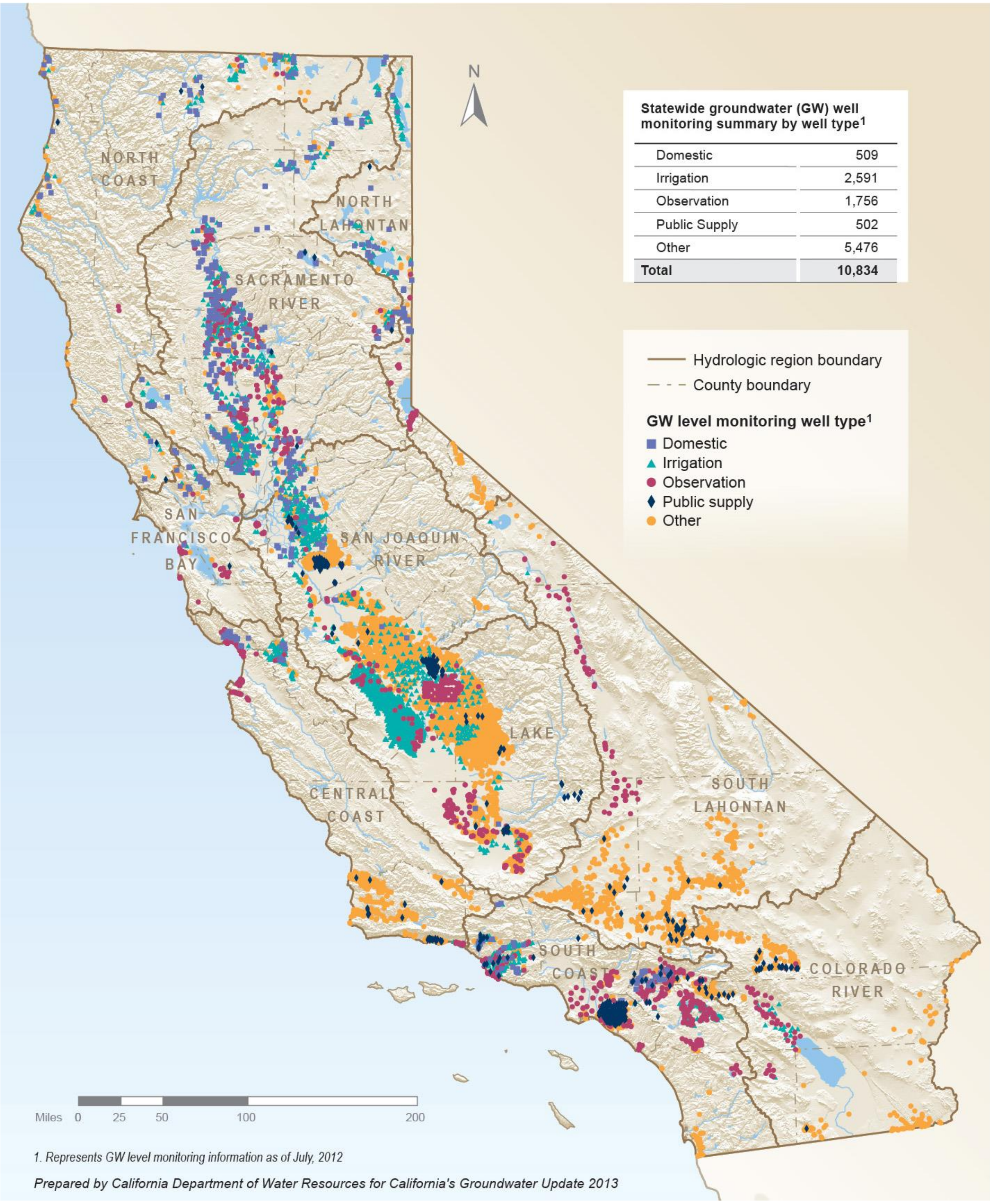


Figure 2-12 California Groundwater Level Monitoring Wells by Monitoring Well Type



Statewide groundwater (GW) well monitoring summary by well type[1]

Domestic	509
Irrigation	2,591
Observation	1,756
Public Supply	502
Other	5,476
Total	**10,834**

1. Represents GW level monitoring information as of July, 2012

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Regional and statewide groundwater quality monitoring information and data are available to the public on DWR's Water Data Library (http://www.water.ca.gov/waterdatalibrary/), the SWRCB's Groundwater Ambient Monitoring and Assessment (GAMA) program Web site (http://www.waterboards.ca.gov/gama/geotracker_gama.shtml), and on the SWRCB's GeoTracker GAMA Web site (http://geotracker.waterboards.ca.gov/). The GAMA program was created in 2000 by the SWRCB to better understand California's groundwater quality issues. The GAMA program was later expanded, as part of the Groundwater Quality Monitoring Act of 2001, resulting in a publicly-accepted plan to monitor and assess groundwater quality in basins that account for more than 95 percent of the state's groundwater use. The GAMA Web site includes a description of the GAMA program and also provides links to published GAMA documents and related reports.

GeoTracker GAMA is an online groundwater information system that provides the public with access to groundwater quality data. The data is geographically displayed and includes analytical tools and reporting features to assess groundwater quality conditions. GeoTracker GAMA allows users to search for more than 60 million standardized analytical test results from over 200,000 wells and contains more than 125 million data records. These data records were obtained from different sources such as RWQCB cleanup sites, CDPH, Department of Pesticide Regulation (DPR), DWR's Water Data Library, USGS GAMA Priority Basin Project, SWRCB GAMA Domestic Well Project, and Lawrence Livermore National Laboratory (LLNL) GAMA Special Studies projects. In addition to groundwater quality data, GeoTracker GAMA contains more than 2.5 million depth-to-groundwater measurements from DWR and the RWQCBs. GeoTracker GAMA also contains hydraulically fractured oil and gas well information from the California Division of Oil, Gas, and Geothermal Resources.

Groundwater quality data in DWR's Water Data Library primarily includes baseline minerals, metals, and nutrient data associated with regional monitoring. Table 2-5 lists agency-specific groundwater quality information. Additional information regarding assessment and reporting of groundwater quality information is listed in the Aquifer Conditions portion of this report.

Land Subsidence Monitoring

Land subsidence has been shown to occur in areas experiencing a significant decline in groundwater levels. When groundwater is extracted from aquifers in sufficient quantity the groundwater level is lowered and the water pressure, which supports the sediment grains structure, decreases. A decrease in water pressure causes more weight from the overlying sediments to be supported by the sediment grains within the aquifer. In unconsolidated deposits, the increased weight from overlying sediments may compact the fine-grained sediments and permanently decrease the porosity of the aquifer and the ability of the aquifer to store water. The partial collapse of the aquifer results in the subsidence of the land surface overlying the aquifer. Elastic land subsidence is the reversible and temporary fluctuation of earth's surface in response to seasonal periods of groundwater extraction and recharge. Inelastic land subsidence is the irreversible and permanent decline in the earth's surface because of the collapse or compaction of the pore structure within the fine-grained portions of an aquifer system (U.S. Geological Survey 1999).

Table 2-5 Statewide Sources of Groundwater Quality Information

Agency	Links to Information
State Water Resources Control Board http://www.waterboards.ca.gov/	Groundwater http://www.waterboards.ca.gov/water_issues/programs/#groundwater) • Communities that Rely on a Contaminated Groundwater Source for Drinking Water http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/index.shtml • Nitrate in Groundwater: Pilot Projects in Tulare Lake Basin/Salinas Valley http://www.waterboards.ca.gov/water_issues/programs/nitrate_project/index.shtml • Hydrogeologically Vulnerable Areas http://www.waterboards.ca.gov/gama/docs/hva_map_table.pdf • Aquifer Storage and Recovery http://www.waterboards.ca.gov/water_issues/programs/asr/index.shtml • Central Valley Salinity Alternatives for Long-Term Sustainability (CV-Salts) http://www.waterboards.ca.gov/centralvalley/water_issues/salinity/ GAMA http://www.waterboards.ca.gov/gama/index.shtml • GeoTracker GAMA (Monitoring Data) http://www.waterboards.ca.gov/gama/geotracker_gama.shtml • Domestic Well Project http://www.waterboards.ca.gov/gama/domestic_well.shtml • Priority Basin Project http://www.waterboards.ca.gov/water_issues/programs/gama/sw_basin_assesmt.shtml • Special Studies Project http://www.waterboards.ca.gov/water_issues/programs/gama/special_studies.shtml • California Aquifer Susceptibility Project http://www.waterboards.ca.gov/water_issues/programs/gama/cas.shtml Contaminant Sites • Land Disposal Program http://www.waterboards.ca.gov/water_issues/programs/land_disposal/ • Department of Defense Program http://www.waterboards.ca.gov/water_issues/programs/dept_of_defense/ • Underground Storage Tank Program http://www.waterboards.ca.gov/ust/index.shtml • Brownfields http://www.waterboards.ca.gov/water_issues/programs/brownfields/
California Department of Public Health http://www.cdph.ca.gov/Pages/DEFAULT.aspx	Division of Drinking Water and Environmental Management http://www.cdph.ca.gov/programs/Pages/DDWEM.aspx • Drinking Water Source Assessment and Protection (DWSAP) Program http://www.cdph.ca.gov/certlic/drinkingwater/Pages/DWSAP.aspx • Chemicals and Contaminants in Drinking Water http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chemicalcontaminants.aspx • Chromium-6 http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chromium6.aspx • Groundwater Replenishment with Recycled Water http://www.cdph.ca.gov/HealthInfo/environhealth/water/Pages/Waterrecycling.aspx

Agency	Links to Information
California Department of Water Resources http://www.water.ca.gov/	Groundwater Information Center http://www.water.ca.gov/groundwater/index.cfm • Bulletin 118 Groundwater Basins http://www.water.ca.gov/groundwater/bulletin118/gwbasins.cfm • California Statewide Groundwater Elevation Monitoring (CASGEM) http://www.water.ca.gov/groundwater/casgem/ • Groundwater Level Monitoring http://www.water.ca.gov/groundwater/data_and_monitoring/gw_level_monitoring.cfm • Groundwater Quality Monitoring http://www.water.ca.gov/groundwater/data_and_monitoring/gw_quality_monitoring.cfm • Well Construction Standards http://www.water.ca.gov/groundwater/wells/standards.cfm • Well Completion Reports http://www.water.ca.gov/groundwater/wells/well_completion_reports.cfm
California Department of Toxic Substance Control http://www.dtsc.ca.gov/	EnviroStor http://www.envirostor.dtsc.ca.gov/public/
California Department of Pesticide Regulation http://www.cdpr.ca.gov/	Groundwater Protection Program http://www.cdpr.ca.gov/docs/emon/grndwtr/index.htm • Well Sampling Database http://www.cdpr.ca.gov/docs/emon/grndwtr/gwp_sampling.htm • Groundwater Protection Area Maps http://www.cdpr.ca.gov/docs/emon/grndwtr/gwpa_maps.htm
U.S. Environmental Protection Agency http://www.epa.gov/safewater/	US EPA STORET Environmental Data System http://www.epa.gov/storet/
U.S. Geological Survey http://ca.water.usgs.gov/	USGS Water Data for the Nation http://waterdata.usgs.gov/nwis

Land subsidence investigations throughout California include various monitoring efforts. Some of these monitoring efforts include elevation surveys along the California Aqueduct, borehole extensometer monitoring, satellite remote sensing studies using interferometric synthetic aperture radar (InSAR), continuous and conventional GPS measurements, and spirit-leveling surveying. In addition, monitoring of ground surface elevations associated with non-land subsidence studies, such as periodic highway elevation surveys, can also result in data that is useful for monitoring and assessing land subsidence. A summary of land subsidence monitoring activities in the Central Valley is provided in Chapters 7, 8, and 9. A general overview of statewide land subsidence conditions is provided under the Aquifer Conditions section of this report. A more recent and comprehensive study of land subsidence caused by groundwater pumping in California is presented in Appendix F.

Statewide Aquifer Conditions

Aquifer conditions and groundwater levels change in response to varying supply, demand, and hydrologic conditions. During years of normal or above-normal precipitation, or during periods of low groundwater use, aquifer systems tend to recharge and respond with rising groundwater levels. Direct and in-lieu recharge programs in California utilize increased runoff and surface water deliveries during years of wet and above-normal precipitation and help recharge local and regional groundwater basins. As a result, if groundwater levels rise sufficiently, they reconnect to surface water systems, contributing to the overall base flow or directly discharging onto the ground surface via wetlands, seeps, and springs. However, in many areas throughout the state, the groundwater table has been disconnected from surface water systems for decades and provides no contribution to base flow.

During dry years or periods of increased groundwater extraction, seasonal groundwater levels tend to fluctuate widely and, depending on the annual amount of natural and managed recharge, may respond with a long-term decline in groundwater levels, both locally and regionally. Excessive lowering of groundwater levels requires impacted well owners to deepen wells or lower pumps to regain access to groundwater. Lowering of groundwater levels also impacts the surface water–groundwater interaction by increasing infiltration rates, capturing groundwater flow that would otherwise have contributed to the base flow of surface water systems, and by reducing groundwater discharge to surface water systems. Extensive lowering of groundwater levels can also result in land subsidence because of the dewatering, compaction, and loss of storage within finer-grained aquifer systems.

In 1980, DWR Bulletin 118-80 identified 11 groundwater basins as being subject to critical conditions of overdraft. These basins, eight of which are located in the southern Central Valley, include the Santa Cruz-Pajaro, Cuyama Valley, Ventura County, Chowchilla, Madera, Kings, Kaweah, Tulare Lake, Tule, and Kern County basins. More than 30 years later, the vast majority of California’s groundwater supplies continue to be extracted from these and other basins throughout the Central Valley and the Central Coast Hydrologic Region.

As previously discussed, the San Joaquin River and Tulare Lake hydrologic regions, where critical overdraft and inelastic land subsidence have been documented, collectively account for approximately 57 percent of the 2005-2010 average annual groundwater extraction in California.

Groundwater extracted from the entire Central Valley accounts for approximately 74 percent of California’s groundwater extraction. The three groundwater basins located outside the Central Valley that were identified in Bulletin 118-80 as being subject to critical conditions of overdraft are located in the Central Coast Hydrologic Region, which is California’s most groundwater-dependent region. Despite significant efforts by local groundwater management entities to reduce overdraft conditions in the Central Valley and in the Central Coast Hydrologic Region, groundwater overdraft conditions persist and will continue in the future unless groundwater is more sustainably managed. Aquifer conditions for all 10 hydrologic regions are discussed in Chapters 3 through 12.

The following overview of statewide aquifer conditions focuses on groundwater basins located within the Central Valley, as publically available spatial and temporal groundwater level data outside the Central Valley was generally insufficient to allow for detailed analysis on a regional scale. Figure 2-11 illustrates the density of wells that were used to determine aquifer conditions on a hydrologic region scale. The overview of aquifer conditions includes a description of groundwater occurrence and movement, estimates of spring 2005 to spring 2010 change in groundwater in storage, a summary of groundwater quality conditions, and a discussion of the effects of groundwater withdrawal on land subsidence. Additional information regarding the methods and assumptions associated with aquifer condition data and analysis is provided in Appendix A.

Groundwater Occurrence and Movement – Central Valley Aquifers

In the simplest of terms, groundwater comes from infiltration of precipitation and surface water systems and moves from areas of higher to lower elevation. Under predevelopment conditions, the occurrence and movement of groundwater was largely controlled by the surface and subsurface geology, the size and distribution of the natural surface water systems, the average annual hydrology, and the regional topography. However, many decades of high-volume groundwater extraction to sustain California's agricultural economy and the state's growing population has considerably affected the natural occurrence and movement of groundwater. Areas of high groundwater extraction tend to redirect and capture groundwater underflow that may otherwise have contributed to nearby surface water systems, leading to varying degrees of surface water depletion. Thousands of high-capacity wells screened over multiple aquifer zones also lend themselves to vertical aquifer mixing, which can additionally alter natural groundwater flow conditions. In addition, infiltration along miles of unlined water conveyance canals, percolation of applied irrigation water, and direct recharge programs create significant groundwater recharge areas where none previously existed.

Analysis of groundwater occurrence and movement was limited to the Central Valley and was evaluated using spring 2005 to spring 2010 groundwater level data. Springtime groundwater levels typically depict the highest groundwater levels of the year and represent a time when annual groundwater demands are at a minimum and aquifer recharge from winter rainfall runoff is at or near the annual maximum. Groundwater contour maps provide a snapshot of groundwater conditions at a particular point in time or between two particular time periods. Groundwater contour maps were developed using groundwater level data that is publically available online from DWR's Water Data Library and DWR's CASGEM system. Additional groundwater level information is publically available from the USGS National Water Information System and from some groundwater management entities throughout California. Hydrologic region-specific groundwater level information is provided in the aquifer conditions sections of Chapters 3 through 12.

The following sections provide an overview of the Central Valley's depth to groundwater, groundwater elevation, and long-term groundwater level trends associated with changing hydrologic conditions and local management actions. Additional information regarding the assumptions and methods associated with groundwater contours and change in storage estimates are provided in Appendix A.

Depth to Groundwater

Understanding and characterizing the local and regional depth to groundwater in basins provides a better understanding of the potential interaction between groundwater and surface water systems, the relationship between land use and groundwater levels, the potential for land subsidence to occur, and the costs associated with well installation and groundwater extraction. Under predevelopment conditions, the depth to groundwater will generally correlate with ground surface elevation; for example, with increasing ground surface elevation there is a corresponding increase in the depth to groundwater. In high-use basins or in conjunctively managed basins, the correlation between ground surface elevation and depth to water will eventually start to breakdown and show significant variability over areas having little change in ground surface elevation.

Figure 2-13 is a spring 2010 depth-to-groundwater contour map for California's Central Valley. Areas having sufficient spring 2010 groundwater level data to develop depth-to-groundwater contours are highlighted in Figure 2-13 by color-ramped contours and are identified as "Reporting Areas." Alluvial basin areas not covered with color-ramped contours are identified as "Non-Reporting Areas" because of a lack of sufficient groundwater level data.

In the northern Central Valley, most of the areas with limited groundwater data fall within the Redding Area Groundwater Basin, the northwestern portion of the Sacramento Valley Groundwater Basin, and the Delta region in the southernmost portion of the Sacramento River Hydrologic Region. In the southern Central Valley, within the San Joaquin River Hydrologic Region, no contours were developed for the sparsely-populated Los Banos Creek Valley Subbasin or for the Yosemite Valley area. In the Tulare Lake Hydrologic Region the areas with limited groundwater elevation data include the Westside Subbasin and the Tulare Lake lakebed area, as well as the western portion of Kern County. Depth-to-groundwater contours were not developed for aquifers in the Westside Subbasin because of the confined nature of the aquifer, and for the Tulare Lake lakebed area because of the limited availability of groundwater level data.

As shown in Figure 2-13, depth to groundwater in the Central Valley is extremely variable from north to south. In the Sacramento Valley Groundwater Basin in the north, the spring 2010 depth to groundwater ranges from a minimum depth of less than 10 feet below ground surface (bgs) to approximately 50 feet bgs in areas adjacent to the Sacramento River and Feather River, to a maximum depth of about 160 feet bgs in the North American Subbasin located east of Sacramento. In the San Joaquin Valley Groundwater Basin, the depth to groundwater in the western half of the valley is shallowest along the valley floor adjacent to the San Joaquin River and its associated tributaries, and deepest along the eastern side of the valley where it abuts the foothills of the Sierra Nevada. On the east side of the valley, wide-spread agriculture development and insufficient surface water supplies have resulted in significant declines in the groundwater table with regional depressions exceeding 250 feet bgs in the northeastern Madera Subbasin, 200 feet bgs in the eastern Turlock Subbasin, and as much as 150 feet bgs in the northeastern Cosumnes Subbasin. The depth to groundwater in the southern portion of the San Joaquin River Hydrologic Region is more pronounced because of multiple factors, including higher annual temperatures and less annual precipitation, which results in more groundwater pumping for crop irrigation.

For the Tulare Lake Hydrologic Region, as shown in Figure 2-13, the depth to groundwater in the northeastern one-third of the region (Kings and Kaweah subbasins) is shallowest along the valley floor adjacent to the Sierra Nevada foothills. Groundwater recharge along the eastside drainages, such as the Kings River, helps maintain spring 2010 groundwater levels at 20 to 60 feet bgs.

Seepage from the Friant-Kern Canal likely also contributes to shallower groundwater levels along the eastern Kings Subbasin. Moving west toward the axis of the valley, groundwater levels deepen to more than 250 feet bgs along the western edge of the Kings Subbasin. Farther to the south in the Kaweah Subbasin, recharge along the eastern edge of the valley and in areas adjacent to the Kaweah and Tule rivers results in shallower groundwater depths in the 30 to 50 feet bgs range. Moving to the west, as groundwater extraction for urban and agricultural uses increases, the depth to groundwater contours become increasingly irregular and variable. Figure 2-13 shows that depth to groundwater increases to about 150 feet bgs near the cities of Lindsay and Tulare. In the Tule and Kern County subbasins, availability of surface water for irrigation has created a more complex distribution of groundwater depths. For areas in the Tule and Kern County subbasins that receive surface water, groundwater levels range from 200 to 300 feet bgs. For groundwater-dependent areas along the east side of the Friant-Kern Canal, the depth to groundwater ranges from 450 to 600 feet bgs. In the southern and southeastern portion of the Kern County Subbasin, the depth to groundwater becomes more variable and complicated because of nearby groundwater pumping, variable imported surface water availability, and large groundwater banking projects. A significant rise in ground surface topography toward the surrounding mountains results in depths to groundwater of 300 to 500 feet or more along the edges of the valley.

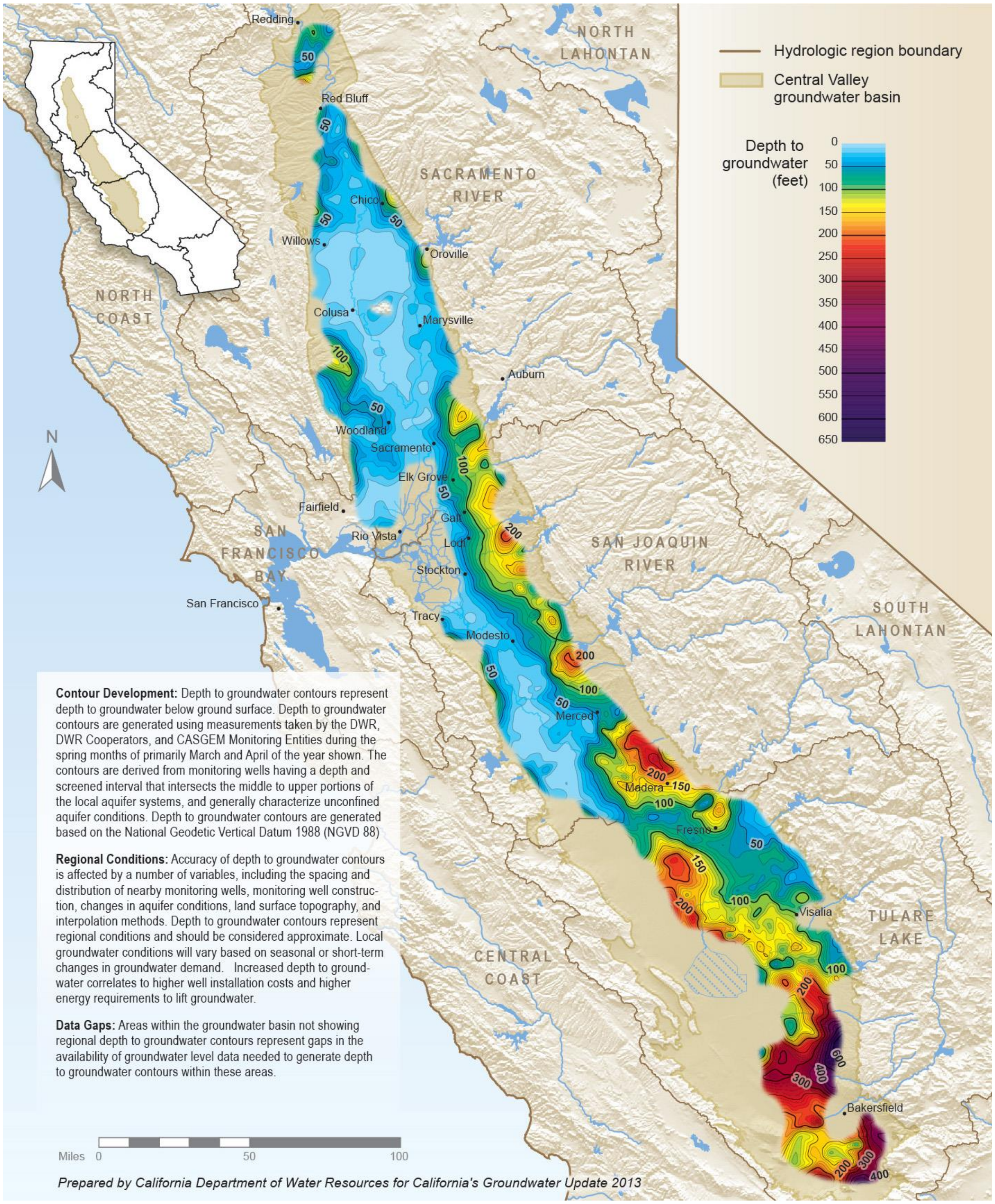
While this statewide depth to groundwater discussion presents a general overview of groundwater levels in the Central Valley, more detailed descriptions and discussions for the Central Valley's hydrologic regions are included in Chapters 7, 8, and 9 of this report. Additional information regarding the assumptions and methods associated with groundwater contours are provided in Appendix A.

Groundwater Elevations

Groundwater elevation contour maps, which provide a good regional estimate of the occurrence and movement of groundwater, were developed using data publically available through DWR's Water Data Library, which contains data collected by DWR and other State, federal, and private cooperators. Under predevelopment conditions, the groundwater elevations typically follow a muted version of the overlying topography. The direction of groundwater flow follows a path perpendicular to the groundwater contours – moving from areas of higher to lower elevation. In aquifer recharge areas, groundwater flow lines tend to diverge from the area in a radial flow pattern. In aquifer discharge areas, or in areas characterized by pumping depressions of the groundwater table, the groundwater flow lines will tend to converge toward the center of the discharge or pumping area. Using similar principles, groundwater elevation contours along gaining stream reaches (streams where groundwater contributes to base flow) will show a groundwater flow pattern that converges upon the stream. Along losing stream reaches (streams that lose water to the aquifer), the groundwater contours will show a groundwater flow pattern that diverges from the stream.

Figure 2-14 is a spring 2010 groundwater elevation contour map for California's Central Valley. The contour lines shown in Figure 2-14 are generally indicative of the unconfined portion of the aquifer system and approximate the elevation of the groundwater table. The general direction of horizontal groundwater movement is shown as a series of arrows along the groundwater flow path. Note that these flow direction arrows do not provide information regarding the vertical

Figure 2-13 Spring 2010 Depth to Groundwater Contours for California's Central Valley



movement of groundwater within the unconfined aquifer system. Similar to the spring 2010 depth to groundwater contours shown in Figure 2-13, groundwater elevation contour lines were developed for only those areas having sufficient groundwater level data and characterized by unconfined to semi-confined aquifer conditions.

In the Sacramento Valley, the regional groundwater movement follows a relatively natural north-to-south flow path from the edges of the valley toward the Sacramento River and nearby drainages. The groundwater flow gradient remains relatively flat near the Sacramento River and along the center axis of the valley where topographic relief is low, but increases rapidly at the edges of the valley as the topographic relief increases. The topographic low point of the Sacramento Valley is the Sacramento-San Joaquin River Delta in the southernmost portion of the valley; in this area, the south-to-north groundwater flow in the San Joaquin Valley converges with the flow from the Sacramento Valley. The Sacramento-San Joaquin River Delta area has limited groundwater level data; however, existing data indicates that groundwater elevations throughout the delta are generally at or slightly below sea level, averaging two to 10 feet bgs.

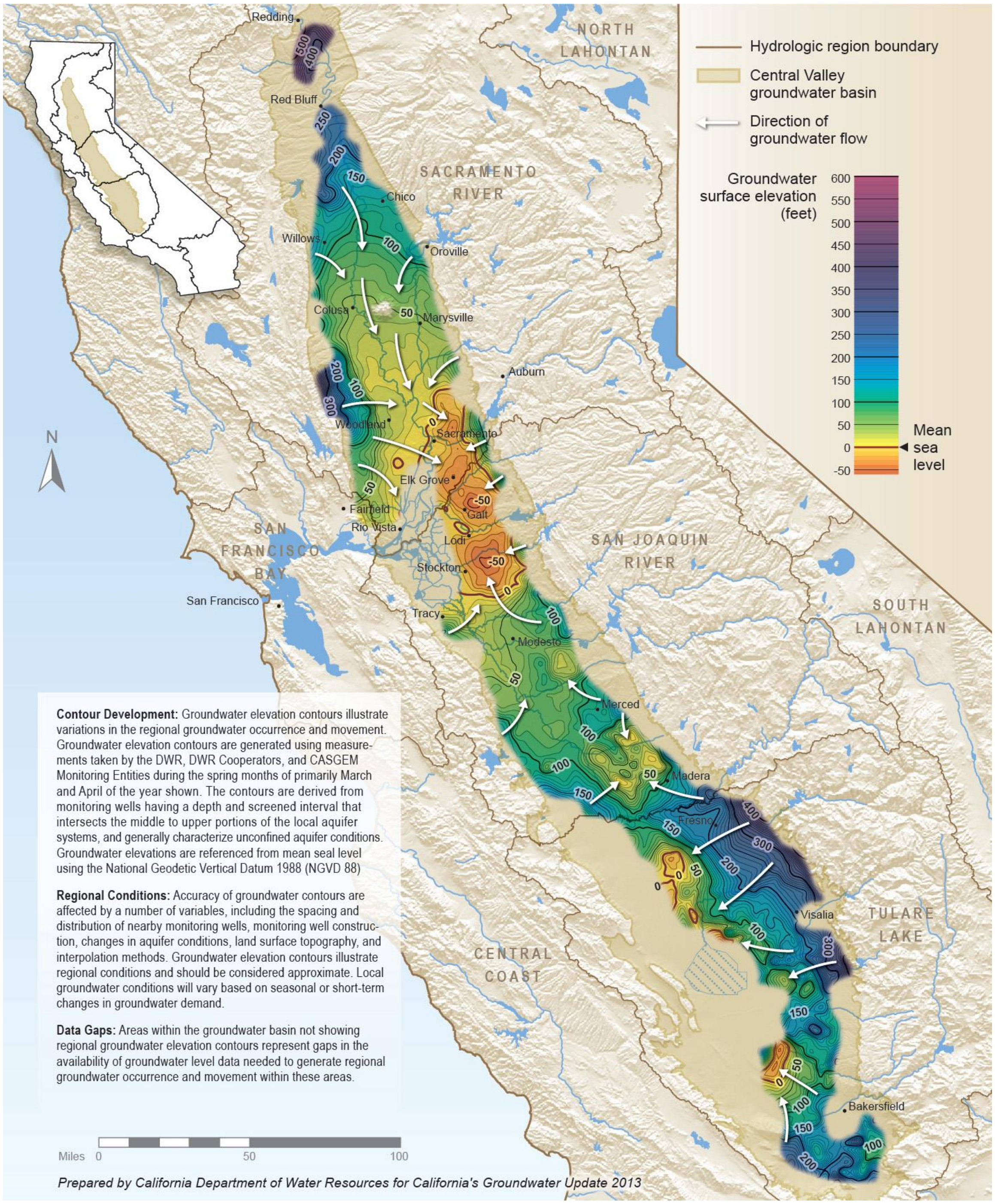
In the Redding Area Groundwater Basin in the northern Sacramento Valley, Figure 2-14 shows that spring 2010 groundwater elevations range from a low of about 390 feet above mean sea level (msl) adjacent to the Sacramento River, to a high of about 590 feet above msl in the northwestern foothill portions of the basin. The Sacramento Valley Groundwater Basin portion shows a more complicated pattern of groundwater movement and occurrence. Groundwater elevations range from below sea level near the Sacramento-San Joaquin River Delta and in portions of the North and South American subbasins to more than 300 feet above msl along the western and northern portions of the basin. Cones of depression of 50 feet below msl have formed around the eastern Cosumnes Subbasin and the Eastern San Joaquin Subbasin near the cities of Galt and Stockton because the annual rate of groundwater pumping exceeding the annual rate of recharge.

In the San Joaquin Valley, groundwater pumping and recharge activities tend to alter the spacing, pattern and overall variability of groundwater elevation contours for some areas. In areas receiving little or no surface water, large groundwater pumping centers have created localized cones of depression of 50 feet below msl, which has caused regional groundwater levels to drop to sea level or below sea level. An example of a groundwater cone of depression in the San Joaquin Valley is the large pumping depression located in the eastern Madera and Chowchilla subbasins, where historic groundwater flows have been altered and now radially flow toward the cone of depression, or pumping center.

Figure 2-14 shows that the spring 2010 groundwater movement in the Tulare Lake Hydrologic Region is generally from the eastern edge of the valley to the axis of the valley. Although groundwater contours were not developed for the west side of the region (Westside, Tulare Lake, and Kern County subbasins), the natural direction of groundwater movement along the west side is generally from the Diablo Range eastward toward the axis of the valley.

The spring 2010 pumping depressions along the western edge of the Kings and Kaweah subbasins tend to capture groundwater from adjacent areas and prevent groundwater from further moving in a normal down-gradient direction. Additional pumping depressions are shown to occur in other subbasins within the region; however, the extent and depth of these depressions are not as large.

Figure 2-14 Spring 2010 Groundwater Elevation Contours for California's Central Valley



Groundwater elevations in the southern San Joaquin Valley range from more than 400 feet above msl along the valley's western boundary to below msl along the valley's axis. More detailed descriptions and discussions of groundwater elevations in the Central Valley are included in Chapters 7, 8, and 9 of this report. Additional information regarding the assumptions and methods associated with groundwater contours and groundwater elevations are provided in Appendix A.

Long-Term Groundwater Level Trends

Depth-to-water measurements collected from a particular well over time can be plotted to create a hydrograph. Hydrographs assist in the presentation and analysis of seasonal and long-term groundwater level variability and trends over time. Because of the highly-variable nature of the aquifer systems within each groundwater basin, and because of the regional differences in annual groundwater extraction, recharge, and surrounding land use practices, the hydrographs selected to depict long-term groundwater level trends do not necessarily capture the extensive variability in statewide aquifer conditions. Rather, the selected hydrographs help "tell a story" of how local aquifer systems respond to fluctuating groundwater extraction and changing resource management practices. The hydrographs are identified according to the State Well Numbering (SWN) system. The SWN identifies a well by its location using the U.S. Public Land Survey System of township, range, and section. More information on the SWN system is provided in DWR's Water Fact No. 7 information brochure (http://www.water.ca.gov/pubs/conservation/waterfacts/numbering_water_wells_in_california__water_facts_7_/water_facts_7.pdf) available at DWR's Groundwater Information Center (http://www.water.ca.gov/groundwater/index.cfm).

Long-term groundwater level hydrographs were developed for each of California's 10 hydrologic regions to help illustrate the local aquifer response to changes in groundwater management and hydrology. Figure 2-15 presents a small subset of the hydrographs selected for California and groups the hydrographs according to five broad themes associated with aquifer demand and recharge.

- Theme 1. Long term groundwater levels remain reasonably stable because of limited demand and adequate recharge.
- Theme 2. Long-term decline in groundwater levels because of annual demand being consistently greater than annual recharge.
- Theme 3. Long-term decline in groundwater levels that have stabilized because of reduced demand, but have not recovered.
- Theme 4. Long-term decline in groundwater levels that have stabilized and improved, because of reduced demand and increased recharge.
- Theme 5. Long-term groundwater levels remain reasonably stable because of implementing managed recharge activities prior to long-term declines.

In addition to grouping by the five themes described above, the hydrographs in Figure 2-15 are color-coded according to their regional location. This statewide selection of groundwater level hydrographs helps characterize the highly-variable nature of groundwater conditions, by region, and by management practices. Additional hydrographs and more detailed discussions regarding groundwater level trends and the management practices they represent are included in the hydrologic region discussions provided in Chapters 3 through 12 of this report.

Figure 2-15 Selected Hydrographs for California, Page 1

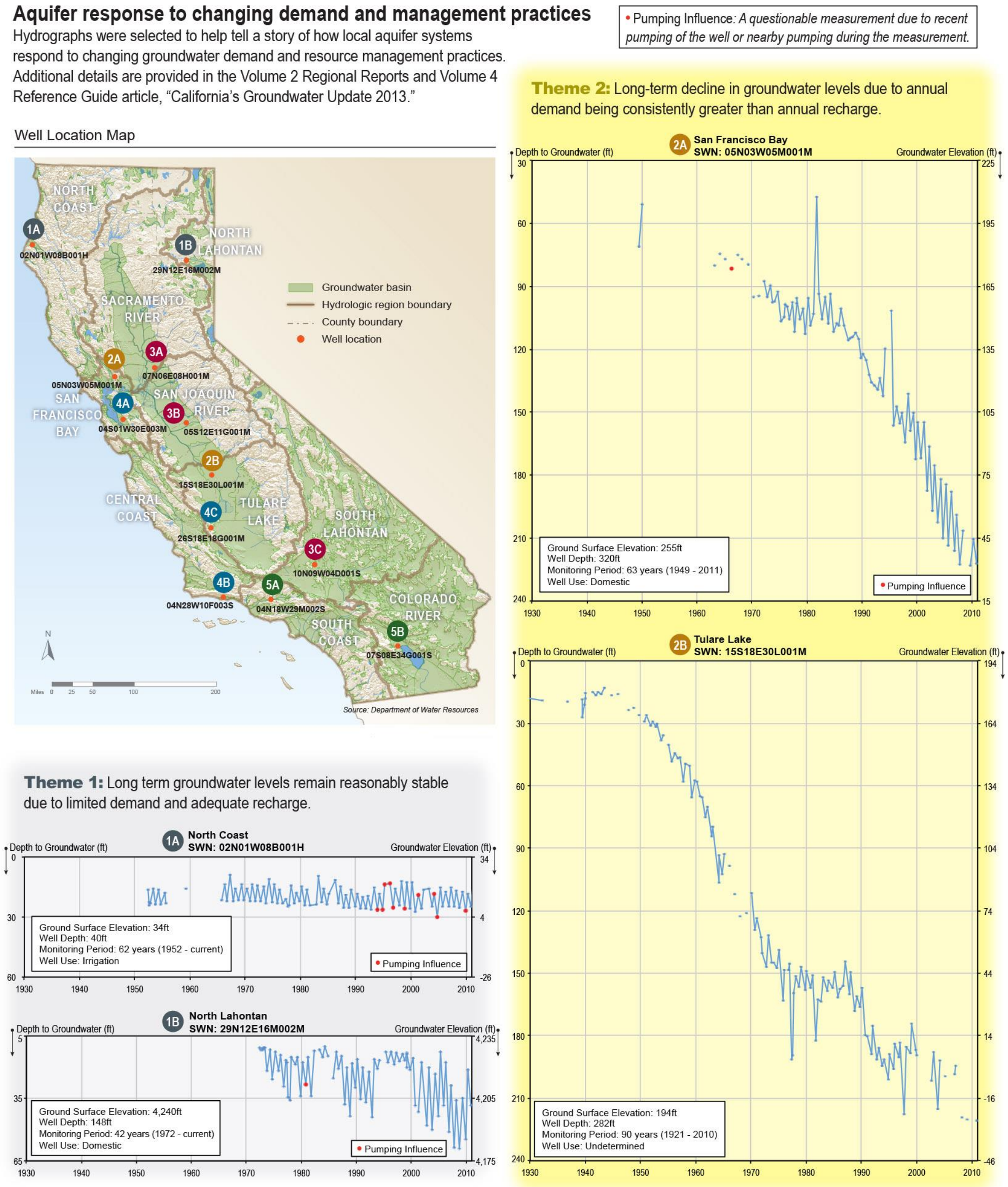
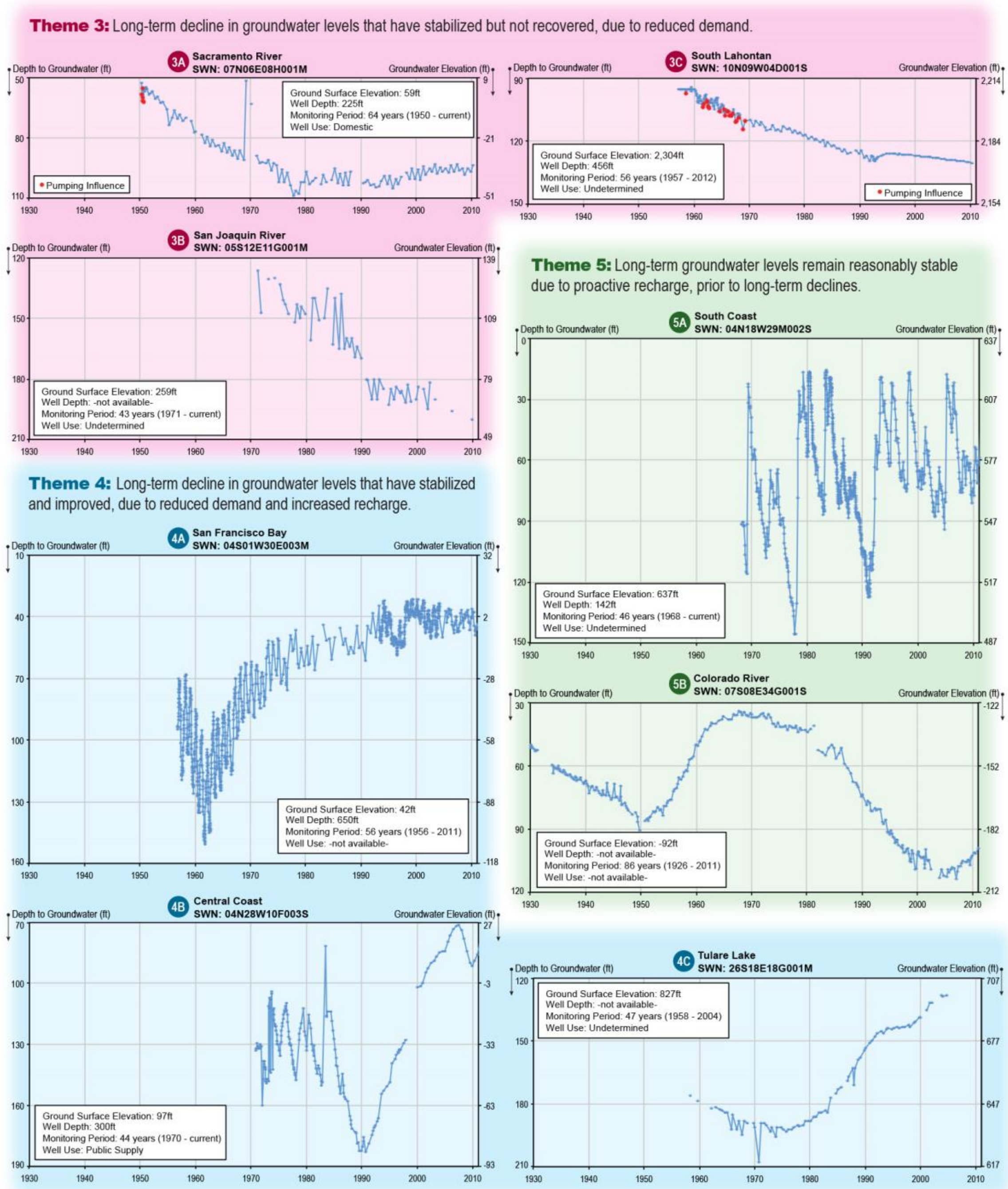


Figure 2-15 Selected Hydrographs for California, Page 2



Change in Groundwater in Storage

Change in groundwater in storage is the difference in groundwater volume between two different time periods. Change in groundwater in storage is calculated by multiplying the difference in groundwater elevation between two time periods, by the overlying basin area, and by the average specific yield (or volume of pore space from which groundwater may be extracted).

Evaluating the annual change in groundwater in storage over a series of years helps identify aquifer responses to changes in hydrology, land use, and groundwater management. If the change in storage is negligible over a period represented by average hydrologic and land use conditions, the basin is considered to be in equilibrium. However, declining groundwater levels and storage during years of average hydrology and land use does not always indicate basin overdraft or unsustainable management — some additional investigation is typically required. Use of groundwater in storage during years of diminishing surface water supply, followed by active recharge of the aquifer when surface water or other alternative supplies become available, is a recognized and acceptable approach to conjunctively managing a groundwater basin. Additional information regarding the risk and benefits of conjunctive management in California can be found in *California Water Plan Update 2013*, Volume 3, Chapter 9, "Conjunctive Management and Groundwater Storage."

Annual and cumulative change in groundwater in storage for the Central Valley was calculated between 2005 and 2010 using spring groundwater elevation data, a range of specific yield values for the unconfined aquifer system, and a standardized geographic information systems (GIS) data processing tool developed by DWR. Spring groundwater levels were used because of the tendency toward aquifer stability during the spring months. Beginning the change in storage calculations in 2005, a relatively average water year, allows for better comparison of the annual and cumulative change in storage values in subsequent years.

One key piece of data required for the change in groundwater storage tool is specific yield values for aquifers. Data from two vetted models were assessed for use for the change in groundwater in storage tool; the DWR California Central Valley Groundwater-Surface Water Simulation Model (C2VSim, 2013) and the USGS Central Valley Hydrologic Model (CVHM 2009). These models have compiled and developed specific yield data for the Central Valley in a format readily useable in GIS. Based on data included in C2VSim and CVHM, minimum and maximum specific yield values of 0.07 and 0.17 were determined to be a good approximation of the range of aquifer storage parameters for the unconfined aquifers in the Central Valley. As with the groundwater elevation contour maps, groundwater basins having insufficient data to annually contour and compare the year-to-year changes in groundwater elevations were identified as “Non-Reporting” areas, and therefore, change in groundwater in storage was not estimated for these areas.

A standardized GIS tool was developed by DWR to generate annual groundwater elevation contours and subsequent change in storage estimates. The primary goal of using a standardized GIS tool was to implement a repeatable and transparent process for compiling groundwater elevation data and determining change in storage estimates. The GIS tool is intended to be for basin scale assessment of change in groundwater in storage and is not intended for local scale project analysis. Changes in groundwater in storage were calculated using groundwater level data available from DWR's Water Data Library (http://www.water.ca.gov/waterdatalibrary/) and DWR's CASGEM system (http://www.water.ca.gov/groundwater/casgem/). Additional information regarding the methods and assumptions for calculating change in storage is provided in Appendix E.

Spring 2005 to Spring 2010 Change in Groundwater in Storage

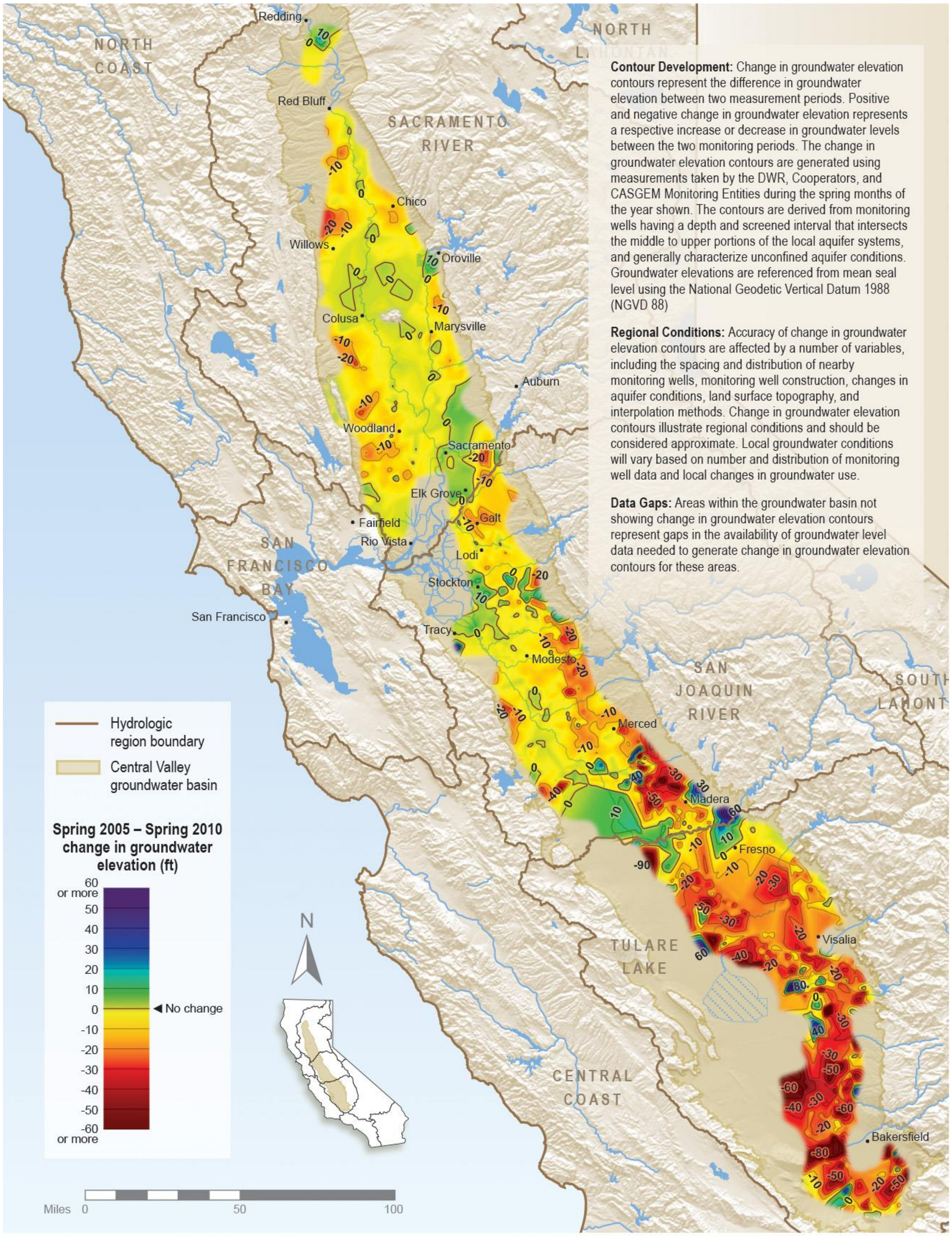
Figure 2-16 is a spring 2005 to spring 2010 change in groundwater elevation contour map for California's Central Valley. The colored contours in Figure 2-16 represent lines of equal change in groundwater elevation between spring 2005 and spring 2010. As shown in Figure 2-16, groundwater elevations in the southern Central Valley declined substantially more than groundwater elevations in the northern Central Valley. While the northern valley saw small, localized groundwater elevation declines of as much as 30 feet between spring 2005 and spring 2010, the southern valley saw large, local and regional groundwater elevation declines of as much as 100 feet or more during the same period of analysis. Figure 2-16 also displays the 2005-2010 annual and cumulative change in groundwater in storage estimates for each of the hydrologic regions that represent the Central Valley. Hydrologic region-specific figures and tables are included in Chapters 7, 8, and 9 of this report.

Table 2-6 presents the average annual change in groundwater elevation for the entire Central Valley, as well as the cumulative valley-wide elevation change during the period of analysis. Table 2-6 also shows the annual estimated range of storage change for the entire Central Valley, based on the minimum and maximum range of specific yield values used, as well as the cumulative change in storage for the 2005 to 2010 period. Table 2-6 includes the reporting area used to calculate the change in storage estimates for the Central Valley – the total non-reporting area is also shown.

Figure 2-17 shows the annual and cumulative change in storage for the entire Central Valley between spring 2005 and spring 2010 – this figure is a composite of the three hydrologic regions individually displayed in Figure 2-16. The bottom of Figure 2-17 also indicates the water year type (wet, above normal, below normal, dry, and critical) based on the Sacramento and San Joaquin River water year indices. Additional change in storage tables and figures for the subbasins within the Central Valley are provided in Appendix E.

Table 2-6 and Figure 2-17 show that the annual change in groundwater elevation and related estimate of change in groundwater in storage for the entire Central Valley generally correlates with the annual precipitation or water-year type. The 2005-2006 period is identified as a wet year, while the subsequent four periods are characterized as either dry, critical, or below normal water years. During the spring 2005 to spring 2006 period, the groundwater levels throughout the entire reporting area in the Central Valley increased an average of 3.6 feet, with a resulting increase in groundwater in storage between 2,148 taf and 5,218 taf, based on the range of specific yield values. Between spring 2006 and spring 2010, however, each of the water years was below normal, dry, or critical, which resulted in withdrawal of groundwater from storage.

Figure 2-16 Change in Groundwater Elevation Contour Map for California's Central Valley (Spring 2005-Spring 2010)



Prepared by California Department of Water Resources for California's Groundwater Update 2013

Figure 2-17 Annual Change in Groundwater in Storage for California's Central Valley (Spring 2005-Spring 2010)

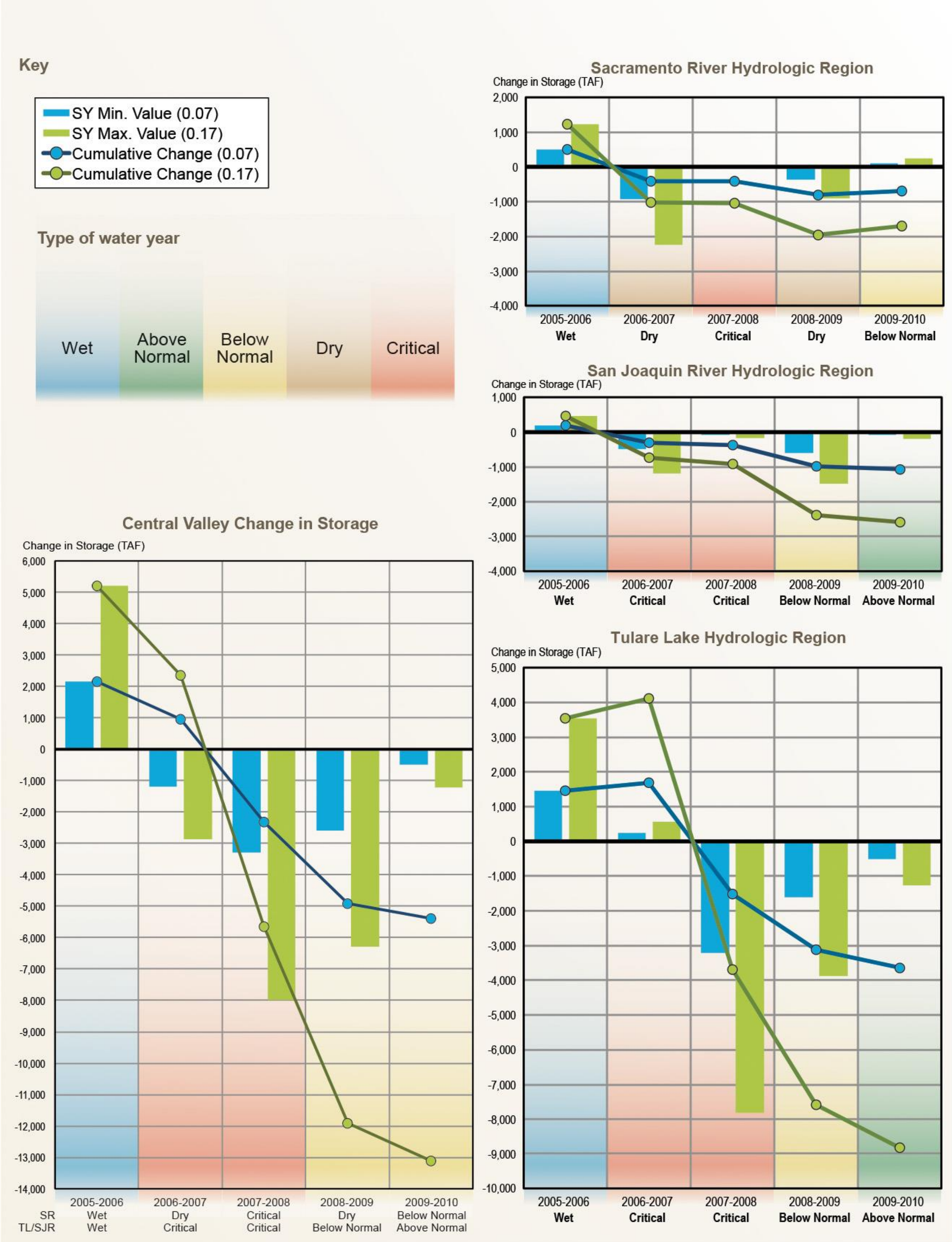


Table 2-6 Annual Change in Groundwater in Storage for California's Central Valley (Spring 2005-Spring 2010)

Period Spring/Spring	Average Change in Groundwater Elevation (ft)	Estimated Change in Groundwater in Storage (taf)	
		Assuming Specific Yield = 0.07	Assuming Specific Yield = 0.17
2005-2006	3.6	2,148	5,218
2006-2007	-2.0	-1,179	-2,863
2007-2008	-5.5	-3,288	-7,984
2008-2009	-4.3	-2,584	-6,276
2009-2010	-0.8	-497	-1,209
Total (2005-2010)	**-9.0**	**-5,400**	**-13,114**

Notes:
ft = feet, taf = thousand acre feet
Groundwater elevation and change in storage estimates are calculated within reporting area only.
Reporting area: 8,588,247 acres.
Non-reporting area: 4,232,587 acres.

While each of the water years between spring 2006 and spring 2010 showed a lowering of groundwater elevation and a negative change in storage, the largest single-year decline occurred between spring 2007 and spring 2008 when the water year was determined to be critical. During this time, the average decrease in groundwater elevation was 5.5 feet throughout the entire Central Valley, with an associated loss of groundwater in storage between 3,288 taf and 7,984 taf. As shown in Table 2-6 and Figure 2-17, the average Central Valley-wide decline in groundwater elevation between spring 2005 and spring 2010 was 9.0 feet, with an associated reduction of groundwater in storage between 5,400 taf and 13,114 taf.

Previous estimates of groundwater overdraft in California suggested that California's aquifers statewide were being overdrafted between 1 maf and 2 maf per year. Based on the results of the change in storage tool described above, the reduction in groundwater in storage within the reporting area of the Central Valley is estimated to be between 1.1 maf and 2.6 maf per year between spring 2005 and spring 2010.

Statewide Groundwater Quality

Effective groundwater management helps to ensure that both groundwater quality and quantity are maintained. Many of the most pressing challenges associated with groundwater quality can be broken down into three categories: (1) nitrate and other salts, (2) industrial chemicals, and (3) naturally-occurring compounds. Nitrate and salt problems are generally associated with diffuse non-point pollution sources, such as agricultural drainage. Industrial pollutants typically originate from discrete point sources. Naturally-occurring compounds are associated with geologic processes, and human activities often mobilize these compounds into groundwater. Groundwater quality can also be impacted by pumping and declining water levels. In some areas, pumping may cause polluted groundwater or seawater to migrate or be drawn into areas that

Table 2-7 Ten Most Frequently Detected Principal Contaminants in Community Water System Wells

Principal Contaminant	Number of Wells	Number of Community Water Systems	Type of Contaminant
Arsenic	587	287	Naturally occurring
Nitrate	451	205	Anthropogenic nutrient[a]
Gross alpha activity	333	182	Naturally occurring
Perchlorate	179	57	Industrial/military use[a]
Tetrachloroethylene (PCE)	168	60	Solvent
Trichloroethylene (TCE)	159	44	Solvent
Uranium	157	89	Naturally occurring
1,2-dibromo-3-chlropropane (DBCP)	118	36	Legacy pesticide
Fluoride	79	41	Naturally occurring
Carbon tetrachloride	52	17	Solvent

Source: SWRCB, 2013, *Communities that Rely on a Contaminated Source for Drinking Water*.
Note:
[a]Can also be naturally occurring, but typically at levels below maximum contaminant level.

would otherwise not be impacted. A summary of the most pressing regional groundwater quality issues associated with each of California's 10 hydrologic regions can be found in Chapters 3 through 12 of this report. The following groundwater quality information collectively summarizes the statewide details discussed in the hydrologic region chapters.

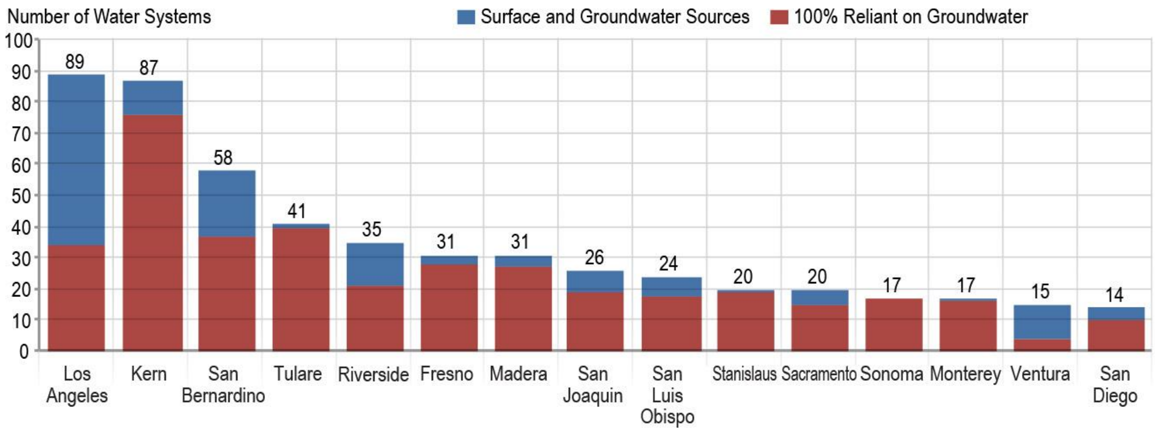
Groundwater Quality at Community Drinking Water Wells

In 2013 the SWRCB completed its report to the legislature, *Communities That Rely on a Contaminated Groundwater Source for Drinking Water*. The report focused on chemical contaminants found in active groundwater wells used by community water systems (CWSs) and reflected the raw, untreated groundwater quality and not necessarily the water quality that is served to these communities. Community water systems are defined under the California Health and Safety Code (Section 116275) as "public water systems that serve at least 15 service connections used by yearlong residents or regularly serve at least 25 yearlong residents of the area served by the system." The report identified 680 CWSs that, prior to any treatment, rely on a contaminated groundwater source for their drinking water. Figure 2-18 shows the 15 counties (out of 58 counties in California) with the greatest number of CWSs that rely upon contaminated groundwater sources. Additional findings included the following highlights:

- 1,659 active groundwater wells, used by 680 CWSs, are contaminated by a principal chemical contaminant.
- 2,584 CWSs rely on groundwater as a primary source of drinking water.
- 8,396 active groundwater wells are associated with the 2,584 groundwater-reliant CWSs.

Statewide, the most prevalent groundwater contaminants affecting CWS wells are arsenic, nitrate, gross alpha activity, and perchlorate. Table 2-7 lists the ten most frequently detected principal contaminants found in CWS wells.

Figure 2-18 Community Water Systems That Rely on a Contaminated Groundwater Source



Source: State Water Resources Control Board, January 2013

While most large CWSs are able to construct, operate and maintain a water treatment system to remove or reduce groundwater contaminants below drinking water standards, small CWSs often cannot afford the high cost to operate and maintain a treatment system and, therefore, some are unable to provide drinking water that meets primary drinking water standards. As of October 2013, there were 163 small CWSs in the state that violated a primary drinking water standard, primarily because of groundwater that has been affected by either arsenic or nitrate contamination (California Department of Public Health 2013).

In addition to the chemical constituents already mentioned, chromium-6 is a groundwater contaminant that is expected to affect many CWSs when a final state maximum contaminant level (MCL) is adopted by CDPH. In 2011, the State Office of Environmental Health Hazard Assessment set a public health goal for chromium-6 at 0.02 parts per billion (ppb). In August 2013, CDPH released a proposed chromium-6 MCL of 10 ppb. Chromium-6 is found to occur naturally in the environment at low levels, but there are also areas in the state that are contaminated because of historic industrial use such as manufacturing of textile dyes, wood preservation, leather tanning, and anti-corrosion coatings (California Department of Public Health 2012).

Groundwater Quality – GAMA Priority Basin Project

The GAMA Priority Basin Project was initiated to provide a comprehensive baseline of groundwater quality in California and assess higher-use groundwater basins that account for more than 90 percent of all groundwater used in the state. The Groundwater Quality Monitoring Act of 2001 (Water Code Sections 10780-10782.3), otherwise known as AB 599, resulted in a publicly-accepted plan to monitor and assess the quality of all priority groundwater basins — the plan prioritized groundwater basins for assessment based on groundwater use. The GAMA Priority Basin Project monitors groundwater for dozens of chemicals, including emerging contaminants, at very-low detection limits. Monitoring and assessments are on a ten-year cycle, with trend monitoring more frequent. As of June 2013, the USGS had sampled more than 2,300 public supply wells and had developed a statistically-unbiased assessment of the quality of California's drinking water aquifers. The SWRCB collaborates with the USGS and LLNL to implement the

Priority Basin Project (State Water Resources Control Board 2013). A general summary of the GAMA Priority Basin Project is provided in the following sections, while hydrologic region-specific water quality details for the project are provide in Chapters 3 through 12 of this report.

The boundaries of the GAMA Priority Basin Project do not correspond with DWR's Bulletin 118-2003 basin boundaries, but do include all or part of 116 of the 515 Bulletin 118 alluvial groundwater basins in the state. GAMA Priority Basins are defined as groundwater basins that account for:

- 95 percent of all public supply wells.
- 99 percent of all municipal groundwater pumping.
- 90 percent of agricultural groundwater withdrawals.
- 90 percent of all leaking underground storage tank sites.
- 90 percent of all pesticide application in the state.
- 60 percent of the land area in California.

Many public supply wells are located outside the boundaries of a defined groundwater basin. To address these wells, the GAMA Priority Basin Project has included areas outside of DWR-defined basins in areas within the Sierra Nevada and Mojave Desert. The GAMA Priority Basin Project tests for constituents that are a concern in public supply wells, with the goal of providing the public with information that can assist in making informed groundwater management decisions. The list of constituents sampled by the USGS includes the following:

- Low-level VOCs and pesticides.
- Stable isotopes, deuterium, and oxygen-18.
- Tritium-helium/noble gases.
- Emerging contaminants.
- Potential wastewater indicators, pharmaceuticals, perchlorate, 1,4-dioxane, chromium (total and VI).
- Carbon isotopes (C-13, C-14).
- Radon, radium, and gross alpha/beta radioactivity.
- Field parameters; temperature, electric conductivity, dissolved oxygen, turbidity, pH, and alkalinity.
- Major ions and trace elements.
- Arsenic and iron speciation.
- Nutrients (nitrate and phosphates).
- Dissolved organic carbon.
- Total fecal coliform bacteria.

The main goals of the GAMA Priority Basin Project are to improve comprehensive statewide groundwater quality monitoring and to increase the availability of groundwater quality information to the public. This information, as well as additional water quality descriptions, is available on the SWRCB's GAMA Priority Basin Project Web site (http://www.waterboards.ca.gov/gama/priority_basin_projects.shtml) (State Water Resources Control Board 2013). Additional GAMA details are provided on the USGS GAMA Web site (http://ca.water.usgs.gov/projects/gama/).

Groundwater Quality in Domestic Wells

Private domestic wells are typically used by either single-family homeowners or other groundwater-reliant systems which are not regulated by the State. Domestic wells generally tap shallower-depth groundwater, making them more susceptible to contamination from historic and recent land use practices. Many domestic well owners are often unaware of the quality of their well water because the State does not require individual well owners to test their water quality. Although private domestic well water quality is not regulated by the State, it is a concern to local health and planning agencies and to State agencies in charge of maintaining water quality.

In an effort to assess domestic well water quality, the SWRCB's GAMA Domestic Well Project (http://www.waterboards.ca.gov/water_issues/programs/gama/domestic_well.shtml) samples domestic wells for commonly-detected chemicals at no cost to well owners who voluntarily participate in the program. Results are shared with the well owners and used by the GAMA Program to evaluate the quality of groundwater used by private well owners. As of 2011, the GAMA Domestic Well Project had sampled 1,146 wells in the following six counties: Monterey, San Diego, Tulare, Tehama, El Dorado and Yuba. The GAMA Program found that most private well owners participating in the program have not had their well sampled previously.

The GAMA Domestic Well Project tests for chemicals that are most commonly a concern in domestic well water. These constituents include the following:

- Bacteria (total and fecal coliform).
- General minerals (sodium, bicarbonate, calcium, others).
- General chemistry parameters (pH, TDS, and others).
- Inorganics (lead, arsenic and other metals) and nutrients (nitrate, others).
- Organics (benzene, toluene, PCE, MTBE, and others).

In addition to the above constituents, the GAMA Domestic Well Project may analyze for locally known chemicals of concern. Some of these chemicals include radionuclides, perchlorate, pesticides, and chromium-6. Complete results of the GAMA Domestic Well Project can be found on the SWRCB's Domestic Well Project Web site and summaries of the relevant data are included in the hydrologic region discussions in Chapters 3 through 12 of this report.

Groundwater Quality Protection

In the Central Valley a number of efforts are underway to protect groundwater quality. The Central Valley RWQCB has approved a Groundwater Quality Protection Strategy and is working on a comprehensive salt and nitrate management plan through the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS), which is a collaborative basin planning effort to address problems with salinity and nitrates in surface water and groundwater. These efforts are discussed in the following sections.

Groundwater Quality Protection Strategy

In 2008 the Central Valley RWQCB started a public process to solicit information from stakeholders on groundwater quality protection concerns in the entire Central Valley region.

In 2010, the Central Valley RWQCB approved the following recommended actions:

- Develop a salt and nutrient management plan.
- Implement a groundwater quality monitoring program.
- Implement groundwater protection programs through IRWM plan groups.
- Broaden public participation in all programs.
- Coordinate with local agencies to implement a well design and destruction program.
- Develop a groundwater database.
- Alternative dairy waste disposal.
    - Develop individual and general orders for poultry, cattle feedlots and other types of combined animal feeding operations (CAFOs).
- Implementation of long-term irrigated lands regulatory program (ILRP).
- Reduce site cleanup backlog.
- Draft waiver following recently adopted regulation based on AB 885.
    - Update guidelines for waste disposal for land developments.
- Develop methods to increase number of facilities regulated.

Additional information on Central Valley RWQCB's Groundwater Quality Protection Strategy is available at:
http://www.waterboards.ca.gov/centralvalley/water_issues/groundwater_quality/index.shtml.

Salt and Nutrient Management Plans

The SWRCB's Recycled Water Policy was adopted in 2009 (Resolution No. 2009-0011) with a goal of managing salt and nutrients from all sources on a basin-wide or watershed-wide basis. This policy requires the development of regional or sub-regional salt and nutrient management plans for every groundwater basin/subbasin in California, and each plan must include monitoring, source identification, and implementation measures.

Throughout the Central Valley, and particularly in the Tulare Lake Hydrologic Region which is a closed basin, participating in the development of the salt and nitrate management plan is of paramount importance to improve water quality in the Central Valley and provide for a sustainable economic and environmental future. The CV-SALTS is a strategic initiative to address problems with salinity and nitrates in surface water and groundwater in the Central Valley.

The long-term plan developed under CV-SALTS will identify and require implementation of management measures aimed at the reduction and/or control of major sources of salt and nitrate as well as support activities that alleviate known impairments to drinking water supplies. Since this issue impacts all water users (stakeholders) in the Central Valley, it is important that all stakeholders participate in CV-SALTS to be part of the development and have input on the implementation of salt and nitrate management within the Central Valley. For the Central Valley, the only acceptable process to develop the salt and nutrient management plans required under State policy (State Water Resources Control Board 2009) is through CV-SALTS. Eventually, the salt and nitrate management plans will provide guidance across all the Central Valley RWQCB's regulatory and non-regulatory programs on how to address salinity and nitrate concerns.

The salt and nitrate management plan will include basin plan amendments that establish regulatory structure and policies to support basin-wide salt and nitrate management. The regulatory structure will have five key elements: (1) refinement of the agricultural, municipal, and domestic supply and groundwater recharge beneficial uses; (2) revision of water quality objectives for these uses; (3) establishment of policies for assessing compliance with the beneficial uses and water quality objectives; (4) establishment of management areas where there are large scale differences in baseline water quality, land use, climate conditions, soil characteristics and existing infrastructure, and where short and long term salt and/or nitrate management is needed; and (5) an overarching framework to provide consistency for the development of plans within the management areas to facilitate implementation efforts and ensure a sustainable future. Additional information on CV-SALTS is available online at: http://cvsalinity.org/ and http://www.waterboards.ca.gov/centralvalley/water_issues/salinity/index.shtml.

Land Subsidence

Land subsidence, which is most often identified as the sinking elevation of the ground surface, is caused by a variety of natural or induced conditions. Potential irreversible damage may include permanent inundation of coastal areas because of land settling and subsequent flooding, losses of aquifer storage, and disruption and damage of infrastructure such as wells, canals, reservoirs, rail lines, and aircraft runways. Subsidence can alter topographic relief, rupture the land surface, and modify and reduce the capacity of flood pathways, which can result in long-lasting and disastrous environmental damage. Overdraft resulting from unsustainable groundwater pumping is the major cause of subsidence in California. Overdraft and land subsidence has been documented in the San Joaquin Valley, the Santa Clara Valley, Antelope Valley, and in some coastal and southern basins in California.

Overdraft in some of the coastal and southern basins was reduced or eliminated by local groundwater management efforts, local regulation, or adjudication. Land subsidence in the Santa Clara Valley has been effectively arrested by implementing groundwater management practices, which include importing surface water and constructing dams, canals, and recharge ponds to facilitate conjunctive management programs. In the Antelope Valley, despite a shift in land use from agriculture to urban development, groundwater levels remain near historic lows and land subsidence will likely continue to occur unless groundwater levels can recover (U.S. Geological Survey 2011). In the San Joaquin Valley, however, the Tulare Lake Hydrologic Region uses the largest amount of groundwater in the state, almost double the amount used by the San Joaquin River Hydrologic Region. As a result, the Tulare Lake Hydrologic Region has experienced more overdraft than any other region in the state; more than triple the estimated loss of groundwater in storage compared to the San Joaquin River Hydrologic Region. Because of the continued heavy-reliance upon groundwater throughout the San Joaquin Valley, overdraft, as well as land subsidence, will continue to occur unless groundwater management actions and land use control can effectively halt or reverse the existing trends. Additional discussions of land subsidence monitoring and land subsidence conditions are provided in the hydrologic region chapters of this report. A recent statewide study of land subsidence resulting from groundwater pumping is presented in Appendix F.

Statewide Groundwater Management

In 1992, the State Legislature provided an opportunity for formal groundwater management with the passage of AB 3030, the Groundwater Management Act (California Water Code Section 10750 et seq.). Groundwater management, as defined in DWR's Bulletin 118 Update 2003, is “the planned and coordinated monitoring, operation, and administration of a groundwater basin, or portion of a basin, with the goal of long-term groundwater resource sustainability.” Groundwater management needs are generally identified and addressed at the local level in the form of GWMPs. If disputes over how groundwater should be managed cannot be resolved at the local level, additional actions, such as enactment of ordinances by local entities with jurisdiction over groundwater, passage of laws by the Legislature, or decisions made by the courts (basin adjudications) may be necessary to resolve the conflict. Under current practice, DWR's role in groundwater management is to provide technical and financial assistance to support local agencies in their groundwater management efforts.

In addition to AB 3030, additional enacted legislation includes SB 1938, AB 359, and provisions of SB x7-6 and AB 1152. These significant pieces of legislation establish, among other things, specific procedures on how GWMPs are to be developed and adopted by local agencies. They define the required and voluntary technical components that must be part of a GWMP and CASGEM groundwater elevation monitoring plan. Assembly Bill 359, introduced in 2011, made changes to the California Water Code that, among other things, requires local agencies to provide a copy of their GWMP to DWR and requires DWR to provide public access to those plans. Prior to the passage of AB 359, which went into effect on January 1, 2013, local groundwater management planning agencies were not required to submit their GWMPs to DWR. As such, the groundwater management information included in this report is based on documents that were readily available or submitted to DWR as of August 2012 and may not be all-inclusive, especially for those plans that were in the process of being finalized and adopted in 2012.

Groundwater management in California also occurs through other resource planning efforts. Urban water management plans (UWMPs) incorporate long-term resource planning to meet existing and future water demands. Agriculture water management plans (AWMPs) advance irrigation efficiency that benefits both farms and the environment. IRWM planning is a collaborative effort to regionally identify and align all aspects of water resource management and planning. Given California’s reliance on groundwater to meet municipal, agricultural, and environmental needs, developing a thorough understanding of the planning, implementation, and effectiveness of existing groundwater management in California is an important first step toward sustainable management of this valuable resource.

The following sections provide an inventory and assessment of GWMPs, groundwater basin adjudications, county ordinances, and other groundwater planning activities in California that were compiled as of August 2012, which was generally the cut-off date for the data collection and analysis phase of this report. Additional groundwater management-related details are presented in the hydrologic region discussions included in Chapters 3 through 12 and on DWR’s Groundwater Information Center Web site.

The Groundwater Management section on DWR's Groundwater Information Center Web site also has the most recent information on California's groundwater management planning efforts, and includes a summary of the Sustainable Groundwater Management Act that was enacted in September 2014. The Sustainable Groundwater Management Act, which is a three-bill legislative package, includes the provisions of SB 1168 (Pavley), AB 1739 (Dickinson), and SB 1319 (Pavley), which requires the formation of locally-controlled groundwater sustainability agencies in high and medium priority groundwater basins with the goal of sustainably managing local groundwater resources. Many of the newly established components in the Sustainable Groundwater Management Act are based on the required, voluntary, and recommended groundwater management components assessed in the following sections.

Statewide Groundwater Management Plan Inventory

Groundwater management information included in this study is based on documents that were readily available or submitted to DWR as of August 2012. The inventory of GWMPs identifies adopting and signatory agencies, the date of plan adoption, the location of plans by county and hydrologic region, and the groundwater basins the plans cover. The inventory also identified how many of the GWMPs were developed based on older 1992 AB 3030 legislation and how many were developed or updated to meet the additional requirements established by the 2002 SB 1938.

For the purposes of the statewide groundwater management assessment conducted as part of the *California Water Plan Update 2013*, an "active" GWMP is one that was prepared, or updated, after SB 1938 was enacted (2002), and prepared in accordance with the provisions of the California Water Code. Some basin management plans or groundwater management policies that have been prepared by local agencies throughout California may not be included on this list, as they were not determined to have been prepared in accordance with the provisions of California Water Code Section 10750 et seq. Although these plans or policies were not included in this first statewide assessment of GWMPs, it does not necessarily mean that the agencies preparing and implementing these plans or policies are not effectively managing their local groundwater basins.

California includes about 158,600 square miles of total land area and approximately 61,900 square miles of Bulletin 118-2003 alluvial groundwater basins. Figure 2-19 shows the location and distribution of the GWMPs within California and identifies pre- versus post-SB 1938 GWMPs. As of August 2012, there were 119 GWMPs identified throughout California. Table 2-8 provides a list of the GWMPs considered for this assessment. Collectively, the 119 GWMPs cover about 42 percent of the Bulletin 118-2003 alluvial basin area and about 20 percent of California's toal land area. Additional details regarding adopting agencies, signatories, plan adoption, and groundwater basins covered by GWMPs are furnished in Chapters 3 through 12.

The inventory and assessment of California's GWMPs determined that 82 of the 119 plans have been developed or updated to include the SB 1938 requirements and are considered "active" for the purposes of the *California Water Plan Update 2013* GWMP assessment. The 82 active GWMPs cover about 32 percent of the Bulletin 118-2003 alluvial basin area. Detailed review of the GWMPs indicated that 35 of the 82 plans address all the California Water Code requirements for groundwater management. Unfortunately, these 35 GWMPs cover only 17 percent of the state's alluvial basin area. A more detailed discussion of the GWMP assessment is provided in the following sections.

Figure 2-20 shows the cumulative number of GWMPs adopted in California per year, based on the adoption dates that were compiled by DWR. It shows that local agencies are generally responsive to the enactment of legislation. The figure indicates that there are two periods of increased GWMP adoptions; the first one occurred after AB 3030 was approved in 1992 and the second one, resulting in a much larger number of GWMPs adopted, occurred after SB 1938 was enacted in 2002.

Statewide Groundwater Management Plan Assessment

In 2011 and 2012, DWR partnered with the Association of California Water Agencies (ACWA) to survey local water agencies about their groundwater management, conjunctive management, and water banking practices in order to build a better understanding of existing regional groundwater management efforts in California. In addition to the information gathered from the DWR/ACWA groundwater management survey, DWR independently reviewed the GWMPs to assess the following:

- How many of the post-SB 1938 (2002) GWMPs meet the six required components included in SB 1938 and incorporated into California Water Code Section 10753.7.
- How many of the post-SB 1938 GWMPs include the 12 voluntary components included in California Water Code Section 10753.8.
- How many of the implementing or signatory GWMP agencies are actively implementing the seven recommended components listed in DWR Bulletin 118 - Update 2003: California's Groundwater.

The groundwater management planning information collected from the DWR/ACWA survey and through DWR's GWMP assessment is not intended to be punitive in nature. It is widely understood that the application of effective groundwater management in California is ripe with jurisdictional, institutional, technological, and fiscal challenges. DWR is committed to assisting local agencies develop and implement effective, locally-planned, and locally-controlled groundwater management programs. DWR is also committed to helping promote State and federal partnerships, and coordinating with local agencies to expand groundwater data collection, management, and planning activities that promote sustainable local groundwater management. The overall intent of the GWMP assessment is to help identify groundwater management challenges and successes, and provide recommendations for local and statewide improvement.

As previously mentioned, information associated with the GWMP assessment conducted for the *California Water Plan Update 2013* is based on data that was readily available or submitted to DWR through August 2012. Requirements associated with the 2011 AB 359 (Huffman) legislation, related to groundwater recharge mapping and reporting, did not take effect until January 2013 and are not included in this GWMP assessment effort. The following information will only address the 82 "active" plans that were determined by DWR to meet some or all of the requirements of SB 1938.

Figure 2-19 Location of Groundwater Management Plans in California

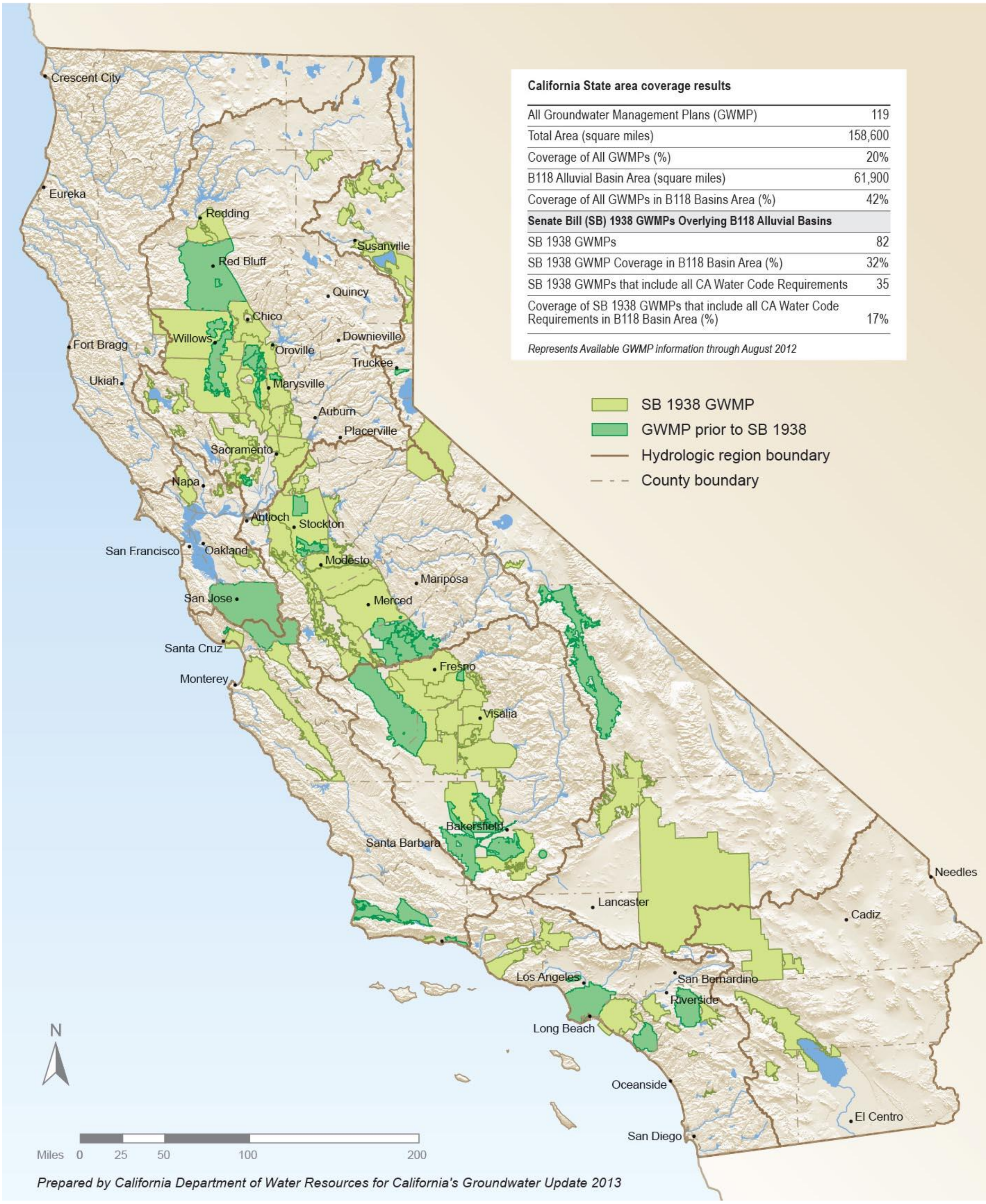


Table 2-8 Groundwater Management Plans in California

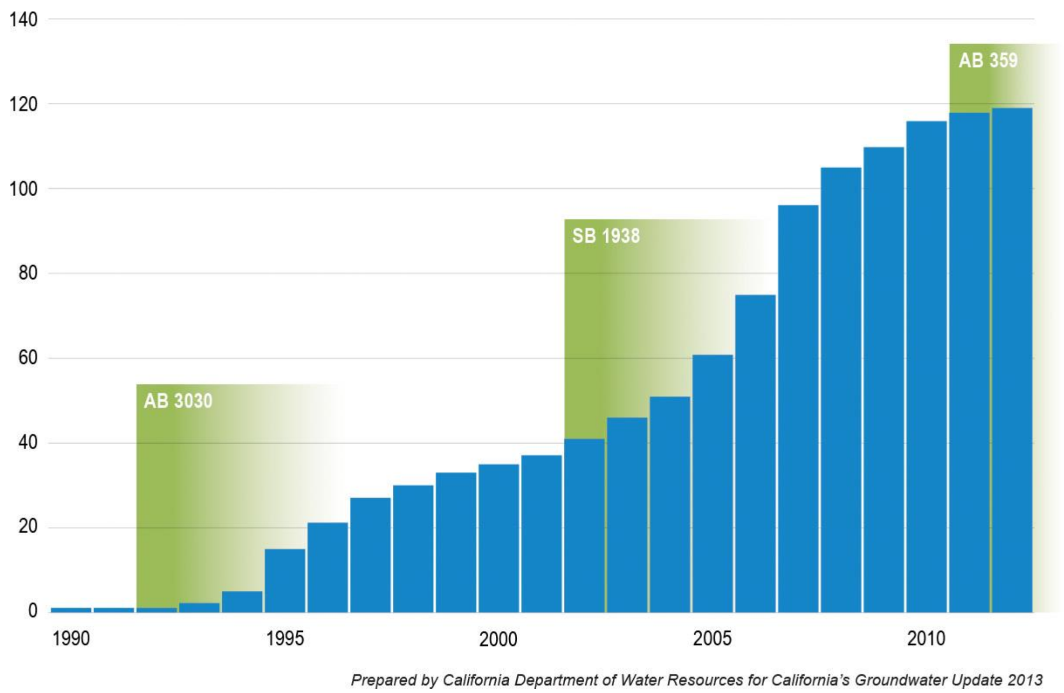
GWMP Title	Year Adopted	HR	GWMP Title	Year Adopted	HR
Alpine County GWMP	2007	NL	Alta ID Amended GWMP	2010	TL
Anderson-Cottonwood ID GWMP	2006	SR	Arvin-Edison WSD GWMP	2003	TL
Bear Valley CSD GWMP	1998	TL	Biggs-West Gridley ID GWMP	1995	SR
Borrego WD GWMP	2006	CR	Buena Vista WSD GW Status and Management Plan	2002	TL
Butte County GWMP	2004	SR	Butte WD GWMP	1996	SR
Calaveras County WD GWMP 2007 Update	2007	SJ	Carpinteria Valley WD GWMP	1996	CC
Castaic Lake WA GWMP Santa Clara River Valley Groundwater Basin East Subbasin	2003	SC	Cawelo WD GWMP	2007	TL
Chowchilla WD-Red Top RCD - Joint Powers Authority GWMP	1997	SJ	City of Corona AB 3030 GWMP	2008	SC
City of Davis and UC Davis GWMP		SR	City of Lincoln GWMP	2003	SR
City of Vacaville GWMP	2011	SR	City of Woodland GWMP	2011	SR
Coachella Valley WD WMP Update	2010	CR	Colusa County GWMP	2008	SR
Consolidated ID GWMP	2009	TL	Deer Creek & Tule River Authority GWMP	2006	TL
Delano-Earlimart GWMP	2007	TL	Diablo WD GWMP	2007	SJ
Dunnigan WD GWMP	2007	SR	Eastern MWD - GWMP West San Jacinto Groundwater Basin	1995	SC
Northeastern San Joaquin Groundwater Basin GWMP	2004	SJ	El Camino ID GWMP	1995	SR
Elsinore Valley MWD - Elsinore Basin GWMP Final Report	2005	SC	Feather WD GWMP	2005	SR
Fox Canyon Groundwater Management Agency GWMP	2007	SC	Fresno Area Regional GWMP	2006	TL
Gillibrand Groundwater Basin GWMP	2007	SC	Glenn Colusa ID GWMP (AB3030)	1995	SR
Glenn County Ordinance 1115 - Groundwater Management	2009	SR	Goleta WD - GWMP	2010	CC
Hemet/San Jacinto Groundwater Management Area WMP	2007	SC	City of Beverly Hills	1999	SC
Humboldt Bay MWD GWMP	2006	NC	Indian Wells Valley Cooperative Groundwater Management Group GWMP	2006	SL
James ID GWMP	2010	TL	Kaweah Delta WCD GWMP	2006	TL
Kern Delta WD GWMP	2003	TL	Kern-Tulare WD, Rag Gulch WD GWMP	2006	TL
Kings County WD GWMP	2011	TL	Kings River CD - Lower Kings Basin GWMP	2005	TL
Kings River WD GWMP	1995	TL	Lake County Watershed Protection District GWMP	2006	SR
Lassen County GWMP	2007	NL	Madera County GWMP	1997	SJ
Madera ID GWMP	1999	SJ	Madera WD GWMP	1997	SJ

GWMP Title	Year Adopted	HR	GWMP Title	Year Adopted	HR
Maine Prairie WD GWMP	1995	SR	Mammoth Basin Watershed GWMP	2005	SL
Maxwell ID GWMP	2004	SR	Mendocino City CSD GWMP and Programs	2007	NC
Merced Groundwater Basin GWMP Update	2008	SJ	Mojave WA Regional WMP	2005	SL
Montecito WD GWMP	1998	CC	Monterey County GWMP	2006	CC
Natomas Area GWMP	2009	SR	North Kern WSD and Rosedale Ranch ID GWMP	1993	TL
North San Joaquin WCD GWMP	1995	SJ	Ojai Basin Groundwater Management Agency MP 2007 Update	2007	SC
Orange County WD GWMP 2009 Update	2009	SC	Orange Cove ID, Hills Valley ID and Tri-Valley WD GWMP	2006	TL
Orland-Artois ID GWMP	2002	SR	Owens Valley and Inyo County - Green Book for The Long Term GWMP	1990	SL
Piru/Fillmore Basins AB3030 GWMP Draft	2011	SC	Placer County Water Agency - Martis Valley GWMP	1998	NL
Rainbow Valley Basin GWMP	2005	SC	Reclamation District 108 GWMP	2008	SR
Reclamation District 1500 GWMP	2012	SR	Reclamation District 2068 GWMP	2005	SR
Richvale ID GWMP	1998	SR	Root Creek WD GWMP	1997	SJ
Rosedale-Rio Bravo Water Storage District GWMP	1997	TL	Sacramento County Water Agency GWMP	2006	SR
Sacramento Groundwater Authority GWMP	2008	SR	San Juan Basin Groundwater Management and Facility Plan	1994	SC
San Joaquin River Exchange Contractors WA GWMP	2008	SJ	San Pasqual Basin GWMP	2007	SC
Santa Clara Valley WD GWMP	2001	SF	Santa Ynez River WCD - Buellton Uplands Groundwater Basin MP	1995	CC
Scotts Valley WD Groundwater Management Plan (AB3030)	1994	CC	Semitropic WSD GWMP	2003	TL
Shafter-Wasco ID GWMP	2007	TL	Shasta County Coordinated GWMP for the Redding Basin	2007	SR
SL&DMWA Canal Service Area GWMP for the Northern Agencies and a Portion of San Joaquin County	2009	SJ	SL&DMWA Canal Service Area GWMP for the Southern Agencies	2009	SJ
Solano ID GWMP Update	2006	SR	Sonoma Valley GWMP	2007	SF
Soquel Creek WD - Soquel-Aptos Area GWMP	2007	CC	South San Joaquin ID GWMP	1994	SJ
South Sutter WD GWMP	2009	SR	Southeast Sacramento Agricultural WA GWMP	2002	SJ
Squaw Valley PSD - Olympic Valley GWMP	2007	NL	Stanislaus & Tuolumne Rivers GW basin Association	2005	SJ
Sutter County GWMP	2012	SR	Sutter Extension WD GWMP	1995	SR
Tehama Country FCWCD - Coordinated GWMP	1996	SR	Tracy Regional GWMP	2007	SJ
Tulare ID GWMP	2010	TL	Tulare Lake Bed Coordinated	1999	TL

GWMP Title	Year Adopted	HR	GWMP Title	Year Adopted	HR
			GWMP		
Turlock Groundwater Basin GWMP	2008	SJ	Twentynine Palms GWMP	2008	CR
Water Resources Association of San Benito County GWMP	2004	CC	West Coast Basin Water Replenishment District GWMP	1998	SC
West Kern WD GWMP	1997	TL	Western Canal WD GWMP	2005	SR
Western Placer County GWMP	2007	SR	Westlands WD GWMP	1996	TL
Westside WD GWMP	2000	SR	Wheeler Ridge - Maricopa WSD GWMP	2007	TL
Yolo County FCWCD GWMP	2006	SR	Yuba County WA GWMP	2010	SR
Zone 7 WA - Livermore-Amador Valley Groundwater Basin - GWMP	2005	SF			

Notes:
AB = Assembly bill, CC = Central Coast, CD = conservation district, CR = Colorado River, CSD = community services district, GW = groundwater, GWMP = groundwater management plan, HR = hydrologic region, ID = irrigation district, MP = management plan, MWD = municipal water district, NC = North Coast, NL = North Lahontan, RCD = resource conservation district, SR = Sacramento River, SF = San Francisco Bay, SJ = San Joaquin River, SC = South Coast, SL = South Lahontan, SL&DMWA = San Luis and Delta Mendota Water Authority, TL = Tulare Lake, UC = University of California, WA = water authority, WD = water district, WMP = water management plan, WSD = water storage district

Figure 2-20 Total Number of Groundwater Management Plans Adopted Per Year



Required GWMP Components

California Water Code Section 10753.7 requires that six components be included in a groundwater management plan for an agency to be eligible for State funding administered by DWR for groundwater projects, including projects that are part of an IRWM program or plan. The required components of a GWMP include the following:

1. **Basin Management Objectives**: Includes components relating to the monitoring and management of groundwater levels within the groundwater basin, groundwater quality degradation, inelastic land surface subsidence, changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin, and a description of how recharge areas identified in the plan substantially contribute to the replenishment of the groundwater basin.
2. **Agency Cooperation**: The plan will involve other agencies that enable the local agency to work cooperatively with other public entities whose service area or boundary overlies the groundwater basin.
3. **Mapping**: The plan will include a map that details the area of the groundwater basin, as defined in the department's Bulletin No. 118, and the area of the local agency that is subject to the plan, as well as the boundaries of other local agencies that overlie the basin in which the agency is developing a groundwater management plan.
4. **Recharge Areas**: Commencing January 1, 2013, the GWMP shall include a map identifying the recharge areas for the groundwater basin, and provide the map to the appropriate local planning agencies and all interested persons, after adoption of the GWMP.
5. **Monitoring Protocols**: The local agency shall adopt monitoring protocols designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence (in basins for which subsidence has been identified as a potential problem), and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin.
6. **GWMPs Located Outside Bulletin 118 Groundwater Basins**: Plans located outside the DWR Bulletin 118 alluvial groundwater basins will incorporate the above components and shall use geologic and hydrologic principles appropriate to those areas.

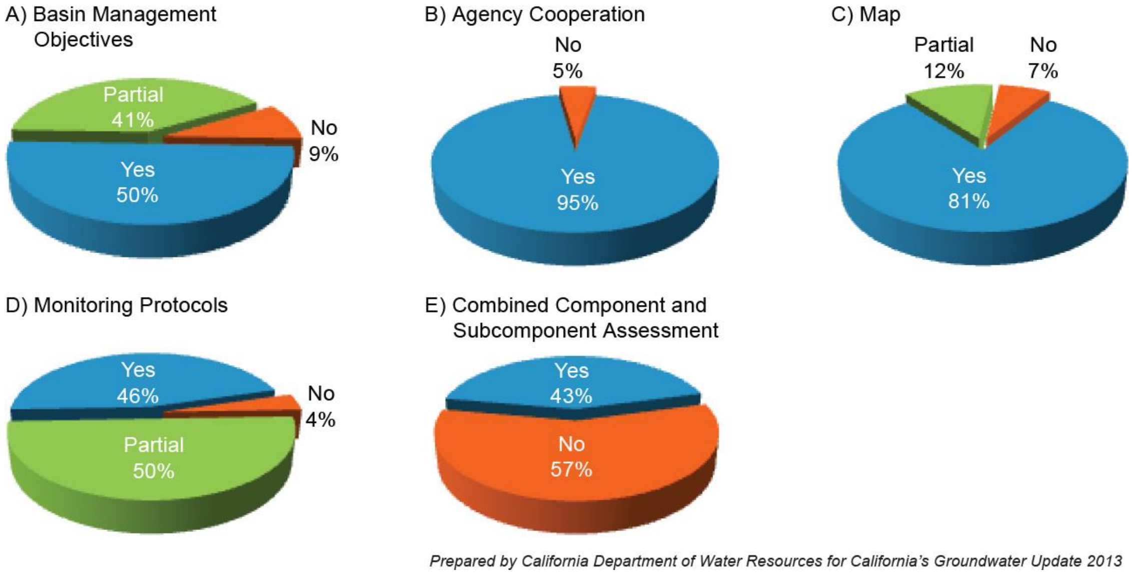
Overall, as previously indicated, DWR determined that 82 of the 119 GWMPs incorporated some or all of the six required components identified above, and 35 GWMPs (43 percent) were determined to adequately address all six components. Table 2-9 identifies what percentage of the 82 active plans meet the required components and subcomponents listed in California Water Code Section10753.7, while Figure 2-21 graphically displays this data.

Basin Management Objectives

The basin management objectives (BMO) assessment consists of four required subcomponents which were individually assessed. The subcomponents include the monitoring and management of: (1) groundwater levels, (2) groundwater quality, (3) inelastic land subsidence, and (4) surface water and groundwater interaction.

The assessment indicated that 41 of the 82 active GWMPs (50 percent) met the overall BMO requirement by providing the necessary measurable objectives, along with the actions which will occur when preset conditions or triggers are met, for each of the four BMO subcomponents.

Figure 2-21 Statewide Assessment of Required GWMP Components



Thirty-four active GWMPs did not meet the overall BMO component but did have the necessary plans for one or more of the required subcomponents; as a result, the GWMP was indicated to be in partial compliance. The remaining seven GWMPs did not meet any of the four BMO subcomponents. Assessments of the individual BMO subcomponents are provided in the following sections.

Monitoring and Management of Groundwater Levels and Groundwater Quality

Approximately 90 percent of the GWMPs provided the necessary BMO objectives for these two subcomponents. The majority of the plans provided the basic objectives and justifications as to why they are necessary. It was recommended in Bulletin 118-2003 that the objectives related to groundwater levels and quality should "have a locally-determined threshold associated with it." Many of the plans stop short of providing that information, but indicate that the thresholds would be determined during implementation. Without the threshold information included in the GWMP, it is not clear how the BMOs will be measured and what actions the will be taken in the event the thresholds are exceeded.

Inelastic Subsidence

Subsidence BMOs were established in 77 percent of the GWMPs; however, many of those plans lacked concise measureable objectives, primarily because no subsidence had been reported in the basins. The cost of creating subsidence monitoring networks is generally prohibitive and typically avoided in areas where the ground surface is stable or where subsidence has not been observed.

In areas where subsidence has been reported and historically been a concern, the GWMPs provided adequate objectives, but many of these regions are relying upon DWR and USGS to maintain their monitoring networks. Most have reported a stabilization of ground surface

Table 2-9 Statewide Assessment of Required GWMP Components

SB 1938 Required Components	Percentage of Plans that Met Requirement
Basin Management Objectives	50%
BMO: Monitoring/Management Groundwater Levels	89%
BMO: Monitoring Groundwater Quality	90%
BMO: Inelastic Subsidence	77%
BMO: SW/GW Interaction and Affects to Groundwater Levels and Quality	57%
Agency Cooperation	95%
Map	81%
Map: Groundwater basin area	88%
Map: Area of local agency	90%
Map: Boundaries of other local agencies	81%
Recharge Areas (January 1, 2013)	Not Assessed
Monitoring Protocols	46%
MP: Changes in groundwater levels	96%
MP: Changes in groundwater quality	91%
MP: Subsidence	78%
MP: SW/GW Interaction and Affects to Groundwater Levels and Quality	55%
Met all Required Components and Subcomponents	43%

Notes:
GW = groundwater, GWMP = groundwater management plan, SW = surface water
Table reflects assessment results of SB 1938 plans that were received by August 2012.

elevation over the past several decades because of reduced groundwater pumping, primarily because of increased access to surface water supplies. During droughts when surface water supplies are reduced, groundwater pumping typically increases and subsidence has been found to either renew or occur at increased rates. Many of the areas with historical subsidence issues have thresholds established on groundwater levels, so that when these levels are exceeded, management actions to increase the basin monitoring for subsidence are initiated or increased. Conjunctive management, which allows for additional recharge into the aquifer systems, is an important part of maintaining stable ground surface elevation.

Surface Water and Groundwater Interaction

The most common BMO subcomponent that was missing or not adequately addressed within the 82 active GWMPs was the requirement for the monitoring and management of surface water and groundwater interaction. Forty-seven (57 percent) of the active GWMPs mentioned this requirement, but were vague about how such a program would be initiated, measured, and managed. After reviewing the surface water-groundwater interaction component, it was evident that agencies did not have a good understanding of what the requirement entailed or what was intended by the legislators when SB 1938 was enacted.

Agency Cooperation

The agency cooperation component was addressed in almost all of the GWMPs, as 78 (95 percent) of the plans included this required component. The GWMPs that did not address this topic failed to adequately identify or include other agencies within their basin in their planning, or more importantly, the sharing of monitoring and management responsibilities that address basin-wide issues.

Mapping

The mapping requirement of SB 1938 has three subcomponents associated with it. The GWMPs are required to provide: (1) one or more maps which depict the GWMP area, (2) the associated Bulletin 118 groundwater basin(s), and (3) all neighboring agencies located within the basin(s). The GWMP review determined that 66 of the 82 active plans (81 percent) met the three mapping requirements, while 10 GWMPs did not provide one or more of the required components. The most common detail left off the maps was identification of the neighboring agencies which share the same basin(s). Six plans did not provide any of the three mapping requirements.

There were a few observations from the review that warrant a discussion on the clarity and organization of the maps. Several plans did not clearly differentiate between agency boundaries and the plan management area. As a result, it required additional research and communication with the plan's lead agency to clarify components of their plan and maps. Additionally, the signatories on the plan were not clearly identified on many of the maps. Several plans included all neighboring agencies when one or more did not become a signatory to the plan. Regarding the organization of the necessary mapping information, too many plans tried to include most of the information on a single map, which made it difficult to understand. While it is possible to combine the three mapping components onto a single map, the better-written plans logically divided the information into two or more maps to reduce the data clutter.

Monitoring Protocols

The monitoring protocols component consists of four subcomponents. Under the requirements of SB 1938, GWMPs are required to establish monitoring protocols for assessing: (1) groundwater levels, (2) groundwater quality, (3) inelastic land subsidence, and (4) surface water and groundwater interaction. In general, these monitoring protocols should directly relate to the BMOs that address these same topics.

The overall results of the assessment for the monitoring protocols component were similar to those for the BMO components. The assessment showed that 38 active GWMPs met each of the four required monitoring protocol subcomponents, while 41 GWMPs did not meet the overall BMO component, but did meet one or more of the required subcomponents. Three GWMPs did not provide adequate monitoring protocols for any of the four subcomponents. The individual subcomponents for monitoring protocols are discussed in the following sections.

Groundwater Levels and Groundwater Quality Monitoring Protocols

The majority of the active GWMPs met the monitoring protocol requirements for measuring groundwater levels (96 percent) and groundwater quality (91 percent). In many GWMPs, it was informative to see maps showing the locations where the various measurements were being conducted. In many plans, the measuring locations were suppressed because of confidentiality concerns.

Inelastic Subsidence Monitoring Protocols

Similar to the BMO component for inelastic land subsidence, 78 percent of the GWMPs included adequate monitoring protocols. Of these, a significant portion of the plans indicated that subsidence was not an issue in their management area or basin, but they would coordinate with DWR and USGS to monitor their basins. The same agencies indicated in their plan that they would develop a detailed management plan to address subsidence should it become an issue in the future. Verification of their statements on current status of subsidence in their basin was not part of the GWMP assessment.

Surface Water and Groundwater Interaction Monitoring Protocols

The most common monitoring protocols subcomponent that was missing or not adequately addressed is associated with surface water and groundwater interaction, as 55 percent of the GWMPs met this requirement. Similar to the BMO component, the majority of the assessed plans mentioned protocols to monitor surface water-groundwater interaction, but were vague about how such protocols would be initiated, measured, and managed.

The biggest issue with meeting this requirement was the agencies' lack of knowledge on how best to address any interaction of surface water and groundwater within their management area. For example, some plans indicated that they would continue to monitor groundwater levels and water quality, but there was no mention on how these measurements would be used to detect surface water-groundwater interaction issues. Other plans provided surface water delivery information and indicated that they would continue to monitor surface water for indications of interaction with groundwater; again, the plans failed to mention how that information would be collected or used.

There were 12 GWMPs that showed a conflict between BMOs and monitoring protocols concerning the surface water and groundwater interaction requirement. Seven plans addressed the BMO requirement but did not address the protocols for monitoring the surface water-groundwater interaction, while five plans addressed the monitoring protocols but not the BMO. It is important to have solid monitoring protocols to help ensure accuracy and consistency for measuring, recording, and presenting field data.

Voluntary GWMP Components

As part of the GWMP review, 12 voluntary components included in California Water Code Section 10753.8 were assessed. The percentage of GWMPs which discussed the voluntary components statewide is shown in Table 2-10. During the GWMP review analysis, some voluntary components were expanded to include subcomponents, which provided more opportunities to meet the various voluntary criteria. However, the reporting and analysis was not done on a subcomponent level. In many cases during the review, if the GWMP included one or more of the subcomponents, full compliance credit was given for the GWMP assessment. Partial compliance was given when the plan left out key planning components, examples of which include missing timelines, vagueness on the specifics of a plan, or vagueness on how a project met the GWMP's goals or objectives.

The voluntary components presented in California Water Code Section 10753.8 include:

1. The control of saline water intrusion.
2. Identification and management of wellhead protection areas and recharge areas.
3. Regulation of the migration of contaminated groundwater.
4. The administration of a well abandonment and well destruction program.
5. Mitigation of conditions of overdraft.
6. Replenishment of groundwater extracted by water producers.
7. Monitoring of groundwater levels and storage.
8. Facilitating conjunctive use operations.
9. Identification of well construction policies.
10. The construction and operation by the local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.
11. The development of relationships with State and federal regulatory agencies.
12. The review of land use plans and coordination with land use planning agencies to assess activities which create a reasonable risk of groundwater contamination.

It is important to note that not all agencies addressed every voluntary component. Based on conversations with a majority of the agencies, it was apparent that if the lead agency determined that the component was not an issue, then there was a good chance it was not addressed or even mentioned in the GWMP. For example, if saline intrusion and overdraft were a non-issue within the plan's boundary, or in some cases, in the groundwater basin, no discussion or actions were taken as part of the planning and implementation. Also, decisions on which components could be achieved by the agency were primarily driven by the availability of funding. The following information highlights those components that were addressed in GWMPs the most.

Saline Intrusion

Saline intrusion can be the result of freshwater displacement by seawater in coastal basins or the migration of high-salinity water in inland groundwater basins. Assessment of the GWMPs that addressed saline intrusion offered a few interesting observations. When all 119 GWMPs (pre- and post-SB 1938) are considered, there are 10 plans located along the coast that cover all or part of a groundwater basin. Four of the 10 plans have provisions for managing coastal sea water intrusion into adjacent freshwater aquifers. The remaining six coastal agencies did not offer any discussion of saline intrusion, or the component was not fully addressed. Likewise, when all 119 GWMPs are considered, there are 34 plans that have provisions for managing saline intrusion in areas not adjacent to the coast. In this case, saline intrusion takes on the form of naturally occurring salts in groundwater. Some agencies consider this type of groundwater as a contaminant that needs to be monitored and, in some instances, mitigated.

Table 2-10 Statewide Assessment of Voluntary GWMP Components

Voluntary Components	Percentage of Plans that Included Component
Saline Intrusion	68%
Wellhead Protection & Recharge	77%
Groundwater Contamination	73%
Well Abandonment & Destruction	87%
Overdraft	83%
Groundwater Extraction & Replenishment	77%
Monitoring	96%
Conjunctive Use Operations	88%
Well Construction Policies	88%
Construction and Operation	52%
Regulatory Agencies	82%
Land Use	71%

Notes:
GWMP = groundwater management plan
Table reflects assessment results of SB 1938 plans that were received by August 2012.

Wellhead Protection and Recharge, Overdraft, and Groundwater Extraction and Replenishment

Between 77 and 83 percent of the GWMPs included discussions associated with groundwater use and groundwater recharge; however, the level of technical detail provided in the GWMPs and the variations in technical analysis were inconsistent throughout the plans. The goal of a GWMP should be to characterize and sustainably manage groundwater resources. If local agencies are not able to properly and accurately identify the components of a water budget, which include inflow (recharge) into a basin and outflow (discharge) from that basin, then it does not appear likely that sustainability goals or BMOs would be attainable.

Groundwater Contamination

The topic of groundwater contamination was addressed in 73 percent of the GWMPs. If groundwater contamination was determined to be a significant issue in the basin, it was approached one of four ways in a GWMP: (1) the plan recognizes that there is groundwater contamination and presents actions to mitigate; (2) the plan identifies projects external to the GWMP that are being conducted by the agency, or identifies other responsible parties that are addressing groundwater contamination within their groundwater management area; (3) the plan states that there are no known groundwater contamination issues and thus the agency continues to postpone significant planning until such time as it might be necessary. Many plans only have provisions to increase the frequency of monitoring and increase sample point density to more precisely track the contaminant in the subsurface; or (4) the plan makes no mention of groundwater contamination.

The first two examples are approaches that represent ways groundwater contamination can be documented in a GWMP if it is known to exist at the time the GWMP is adopted. Remediation requires extensive planning, involves other agencies, and can last for a considerable amount of time. The third approach implies that the agencies responsible for the GWMP are currently monitoring for groundwater contamination, but detecting negative or low results. If a particular contaminant is detected, but is below the MCL, the remediation planning continues to be postponed. The fourth approach, which does not acknowledge groundwater contamination at all, is considered rare; it would be better for the GWMP to document that no groundwater contamination exists or external planning is managing the remediation efforts.

Well Abandonment and Destruction, and Well Construction Policies

Eighty-eight percent of the GWMPs address well construction policies and 87 percent of the plans addressed policies that regulate wells no longer being used (well abandonment and their proper destruction). Regarding policies concerning the life cycle of a well, most plans referenced county ordinances concerning new well construction, abandonment, and destruction. Seventy-five percent of the counties in California have ordinances that define new well construction, with many of those ordinances referencing DWR Bulletin 74 (California Well Standards) as the standards being adhered to. Sixty-five percent of California's counties have policies, via ordinances, concerning the abandonment and destruction of unused wells.

Monitoring of Groundwater Levels and Storage

The monitoring of groundwater levels and storage was addressed by 96 percent of the active GWMPs. Although this component has two parts, the majority of the plans addressed only the monitoring of groundwater levels, which is also a required groundwater management component; very few GWMPs addressed the monitoring of groundwater storage.

Conjunctive Use

Over the years, to promote conjunctive management of surface water and groundwater, California voters and the Legislature have provided significant funding to local agencies for groundwater management. Proposition 13, which was approved by voters in 2000, provided $200 million in grants for feasibility studies, project design, and the construction of conjunctive use facilities. In addition to grant funding, $30 million was provided as loans for local agency acquisition and construction of groundwater recharge facilities and smaller grants for feasibility studies of groundwater recharge projects. Assembly Bill 303, enacted in 2000, created the Local Groundwater Assistance Fund and authorized grants totaling $38.5 million from 2001 to 2009 to help local agencies develop better groundwater management strategies. Proposition 50, which was passed in 2002, provided $500 million for IRWM projects. Although this funding was not specifically targeted at groundwater projects, many of the projects in the regional proposals were designed to expand groundwater storage, desalt brackish groundwater, and improve groundwater quality to make new supplies available. Proposition 84, which was approved in 2006, provided an additional $1 billion for IRWM projects. Perhaps because of the substantial financial assistance provided to local agencies for conjunctive management projects, the topic of conjunctive use is addressed in 88 percent of the active GWMPs.

Construction and Operation

The construction and operation component is addressed in 52 percent of the active GWMPs. This percentage is surprisingly low, since it allows for six different types of projects (groundwater contamination clean-up, recharge, storage, conservation, water recycling, and extraction projects). The GWMP assessment allowed the discussion of one or more of the projects for the plan to be considered as having addressed the component. It is not clear from the plan reviews if the low percentage was because of the timing between the GWMP adoption and the initiation of an acceptable project, because the agencies felt that it was not necessary to include the projects, or both.

Regulatory Agencies

It is believed that 100 percent of the GWMPs intended on working with regulatory agencies, but some plans only identified non-regulatory agencies, such as DWR and USGS; therefore, only 82 percent of the plans met this component.

Land Use

The topic of land use was discussed in brief in 71 percent of the GWMPs reviewed. There were few details found in the assessed GWMPs that provided a direct linkage between the plan's BMOs, goals, or objectives with any land use plan, such as local general plans or regional IRWM plans.

Bulletin 118-03 Recommended GWMP Components

Bulletin 118-2003 contains suggestions on how GWMPs should be developed and provides details that should be included during development of a plan. Bulletin 118-2003, Appendix C provides a list of seven recommended components related to the management, development, implementation, and evaluation of a GWMP that should be considered to help ensure effective and sustainable groundwater management.

1. **Guidance**: Establish an advisory committee to assist in GWMP development and implementation.
2. **Management Area**: Describe the physical setting, aquifer characteristics, and background data.
3. **BMOs, Goals, and Actions***:* Describe how the current or planned actions help to meet the overall management objectives and goals.
4. **Monitoring Plan Description**: Describe groundwater monitoring type, location, frequency, and aquifer interval.
5. **IRWM Planning**: Describe efforts to coordinate with other land use or water management planning.
6. **Implementation**: Develop status reports with management actions, monitoring activities, basin conditions, and achievements.
7. **Evaluation**: Periodic Assessment of conditions versus management objectives.

Table 2-11 lists the seven recommended components outlined in Bulletin 118 and the percentages of active GWMPs that met the criteria. Assessments of the individual recommended components are provided in the following sections.

GWMP Guidance

Based on the plan reviews, 79 percent of the active plans established advisory committees composed of interested parties to help guide the development and implementation of their GWMP.

Management Area

The GWMP assessment determined that 94 percent of the plans provided reasonable details for defining their respective management area. There are several subcomponents that should be addressed when defining a plan's management area, such as the physical setting that includes, but is not necessarily limited to, area, boundaries, participants, land-use, historical and projected water supplies, and total water demands. The recommended component also suggests that a

Table 2-11 Statewide Assessment of DWR Bulletin 118-2003 Recommended GWMP Components

Recommended Components	Percentage of Plans that Included Component
GWMP Guidance	79%
Management Area	94%
BMOs, Goals, & Actions	82%
Monitoring Plan Description	63%
IRWM Planning	78%
GWMP Implementation	87%
GWMP Evaluation	87%

Notes:
BMO=basin management objectives , IRWM-integrated regional water management,
GWMP=groundwater management plan
Table reflects assessment results of SB 1938 plans that were received by August 2012.

GWMP provide a description of the aquifer(s) within the management area and within the groundwater basin; details should include a description of the hydrogeology, historical groundwater level information, groundwater water quality data, any subsidence data, and groundwater-surface water interaction discussions.

BMOs, Goals, and Actions

Eighty-two percent of the active plans followed the suggestions listed in Bulletin 118-2003 that discussed creating a link between the actions, BMOs, and the goals of the GWMP. The overall goal of a GWMP is to maintain reliable long-term beneficial uses of the groundwater within an agency's management area and groundwater basin as a whole. The GWMP assessment determined that the majority of the plans have BMOs that relate to the goals of the GWMP for monitoring groundwater levels, groundwater quality, and inelastic subsidence; however, it was difficult to identify the relationships with the surface water-groundwater interaction BMO and the goals of the plan.

Monitoring Plan Description

The monitoring plan description was addressed in 63 percent of the active plans. This particular component goes further than the required SB 1938 monitoring protocol and the recommended monitoring component, which was discussed previously. What sets this component apart from the others is that it requires maps showing the locations where measurements are going to be taken, what type of measurement will be collected, how often measurements occur, and a description of the physical specifications of the wells being used. The assessment showed that many plans lacked the necessary details in their monitoring plan to meet this recommendation, as the plans were missing maps showing the monitoring grid or how the measurements would be taken. A number of plans cited privacy concerns from landowners regarding the locations and physical descriptions of the wells which prevented the planning agency from sharing that information. The privacy concern is problematic since the data collected cannot be validated, nor correlated, with other similarly-collected data for any regional analysis.

IRWM Planning

Seventy-eight percent of the active plans indicated that the signatory agencies are participating in, or intend to participate in, their regional IRWM planning efforts. Ideally, beyond providing input to the IRWM planning process, the groundwater management agencies should coordinate with neighboring agencies or regions to address land use, zoning, or water management issues.

GWMP Implementation

The topic of GWMP implementation is addressed in 87 percent of the active plans. Plan implementation includes items in reoccurring reports, such as annual reports, that summarize the monitoring results of any trends or activities being conducted to achieve basin management objectives, as well as any updates to the GWMP.

GWMP Evaluation

GWMP evaluation is a periodic review of the management and/or basin area conditions, along with a description of any modifications to an agency's plan. As with the implementation criteria, 87 percent of the active GWMPs include content that indicates a periodic evaluation of the plan will occur. Bulletin 118-2003 does not specify how often the plan evaluations should take place; however, the assessment of active GWMPs indicated that the average timespan for plan evaluation is approximately six years. When considering all 119 plans, the average age of plan evaluation, review, or update increases to more than nine years.

DWR/ACWA Survey – Key Factors for Successful GWMP Implementation

As noted in the previous section, DWR partnered with ACWA to survey its member agencies on various topics covering groundwater management. The survey respondents were asked to provide feedback on which components helped make their GWMP implementation successful. The participants were not asked to rank their responses in terms of importance, but were asked to provide additional insights and list additional components. Table 2-12 contains a summary of the 58 participants that provided a response to the survey and how many times a particular component was selected.

DWR/ACWA Survey – Key Factors Limiting GWMP Success

Survey respondents were also asked to identify challenges that they felt impeded the successful implementation of their GWMP. Table 2-13 has results of the survey that includes responses from 49 participants. Overall, limited funding for groundwater management projects was chosen as the biggest impediment to GWMP implementation, as many groundwater management projects require significant amount of funds to implement and operate. Very few respondents identified data issues, access to planning tools, outreach and education, or lack of governance as a factor that limited their success. Slightly more than a third of the respondents identified unregulated pumping as a limiting factor to their plan's success.

DWR/ACWA Survey – Opinions of Groundwater Sustainability

Finally, local agencies were asked if they were confident in the long-term sustainability of their current groundwater supply. Sixty respondents provided opinions regarding the sustainability of their groundwater supply. Of those that provided responses, 72 percent felt that their current resources were sustainable, while the remaining 28 percent of respondents felt the opposite was true.

The 60 respondents to the sustainability question were matched with their respective hydrologic regions in order to determine the statewide distribution of the responses. Based on the results of the survey, 80 percent of the respondents from the San Joaquin River Hydrologic Region felt their groundwater resources were unsustainable, while 60 percent of the respondents from the Tulare Lake Hydrologic Region and 50 percent from the Central Coast Hydrologic Region indicated their groundwater conditions were unsustainable. By comparison, 33 percent of the respondents from the Colorado River Hydrologic Region and 25 percent from the South Coast Hydrologic Region felt their groundwater resources were unsustainable.

Groundwater Ordinances

Groundwater ordinances are laws adopted by local authorities, such as cities or counties, to manage groundwater. In 1995, the California Supreme Court declined to review a lower court decision (Baldwin vs. Tehama County) that says State law does not occupy the field of groundwater management and does not prevent cities and counties from adopting ordinances to manage groundwater under their police powers. Since 1995, the Baldwin vs. Tehama County decision has remained untested; thus the precise nature and extent of the police power of cities and counties to regulate groundwater is still uncertain.

DWR's Bulletin 118-2003 indicated that 27 counties adopted groundwater management ordinances related to the following activities: forming advisory committees; establishing basin management objectives; and requiring permits for transfers of groundwater out of the basin or county. Efforts conducted as part of *California Water Plan Update 2013* built upon the efforts of Bulletin 118-2003 by adding well construction, abandonment, and destruction ordinances, as well as other approaches to groundwater management via ordinances. The ordinance information for all of California's 58 counties is furnished in Table 2-14.

Table 2-12 Statewide Survey Results for Key Components Contributing to Successful GWMP Implementation

Key Components that Contributed to Success	Respondents
Sharing of ideas and information with other water resource managers	53
Data collection and sharing	55
Adequate surface water supplies	43
Adequate regional and local surface storage and conveyance systems	41
Outreach and education	48
Developing an understanding of common interest	50
Broad stakeholder participation	47
Water budget	39
Funding	47
Time	41
Additional components supplied by participating agencies:	
Conjunctive Use	3
Numeric modeling of groundwater basin	3
Unregulated pumping	2
Stronger coordination with land use agencies	2
Water supply management	2
Land conservation program for overdraft mitigation	1
Legal actions	1
Water Conservation	1
Recharge	1
Agency collaboration on reporting	1
State funding for groundwater management programs	1

Notes:
GWMP = groundwater management plan
Results from an online survey sponsored by DWR and conducted by the Association of California Water Agencies, 2011 and 2012.

Table 2-13 Statewide Survey Results for Factors that Limited the Success of GWMP Implementation

Limiting Factors	Respondents
Participation across a broad distribution of interests	10
Data collection and sharing	7
Funding for groundwater management planning	32
Funding for groundwater management projects	42
Funding to assist in stakeholder participation	21
Understanding of the local issues	9
Outreach and education	5
Groundwater Supply	16
Surface storage and conveyance capacity	19
Access to planning tools	6
Unregulated Pumping	18
Lack of Governance	3

Notes:
GWMP = groundwater management plan
Results from an online survey sponsored by DWR and conducted by the Association of California Water Agencies, 2011 and 2012.

Special Act Districts

Greater authority to manage groundwater has been granted to a few local agencies or districts created through a special act of the Legislature. The specific authority of each agency varies, but the agencies can be grouped into two general categories: (1) agencies having authority to limit export and extraction (upon evidence of overdraft or threat of overdraft); or (2) agencies lacking authority to limit extraction, but having authority to require reporting of extraction and to levy replenishment fees.

There are many Special Act Districts established by the California State Legislature consisting of different authorities that may or may not have groundwater management authority. It was not part of the scope of the *California Water Plan Update 2013* to identify individual types of Special Act Districts or provide a listing of all the established agencies. This report includes the GWMPs that were prepared by these agencies and submitted to DWR, as discussed in the preceding section.

Table 2-14 County Groundwater Ordinances in California

County	Groundwater Management	Guidance Committees	Export Permits	Recharge	Well Abandonment and Destruction	Well Construction Policies
Alameda	-	-	-	-	Yes	Yes
Alpine	-	-	Yes	-	Yes	Yes
Amador	-	-	-	-	Yes	Yes
Butte	Yes	Yes	Yes	-	Yes	Yes
Calaveras	-	-	Yes	-	Yes	Yes
Colusa	-	-	Yes	-	-	Yes
Contra Costa	-	-	-	-	Yes	-
Del Norte	-	-	-	-	Yes	-
El Dorado	-	-	-	-	Yes	Yes
Fresno	-	-	Yes	-	Yes	Yes
Glenn	Yes	Yes	-	-	Yes	Yes
Humboldt	-	-	-	-	-	Yes
Imperial	-	Yes	Yes	Yes	-	-
Inyo	-	-	Yes	-	-	-
Kern	-	-	Yes	-	-	Yes
Kings	-	-	-	-	-	-
Lake	-	-	Yes	-	Yes	Yes
Lassen	Yes	Yes	Yes	-	Yes	-
Los Angeles	-	-	-	Yes	-	-
Madera	-	-	Yes	Yes	Yes	Yes
Marin	-	-	-	-	-	-
Mariposa	-	-	-	-	Yes	Yes
Mendocino	-	-	-	-	Yes	Yes
Merced	-	-	-	-	Yes	Yes
Modoc	-	-	Yes	-	-	Yes
Mono	-	-	Yes	-	Yes	Yes
Monterey	-	-	-	-	Yes	Yes
Napa	-	Yes	-	-	Yes	Yes
Nevada	-	-	-	-	Yes	Yes
Orange	-	-	-	-	-	Yes
Placer	-	-	-	-	Yes	Yes
Plumas	-	-	-	-	Yes	Yes
Riverside	-	-	-	-	Yes	Yes
Sacramento	-	-	Yes	-	Yes	Yes
San Benito	-	-	Yes	Yes	Yes	Yes

County	Groundwater Management	Guidance Committees	Export Permits	Recharge	Well Abandonment and Destruction	Well Construction Policies
San Bernardino	-	-	-	-	Yes	Yes
San Diego	-	-	-	-	-	-
San Francisco	-	-	-	-	Yes	Yes
San Joaquin	-	Yes	Yes	-	Yes	Yes
San Luis Obispo	-	-	-	-	-	Yes
San Mateo	-	-	-	-	Yes	Yes
Santa Barbara	-	-	-	-	-	Yes
Santa Clara	-	-	-	-	-	-
Santa Cruz	-	-	-	-	Yes	Yes
Shasta	-	-	Yes	-	-	-
Sierra	-	-	Yes	-	-	-
Siskiyou	-	Yes	Yes	-	Yes	-
Solano	-	-	-	-	Yes	Yes
Sonoma	-	-	-	-	Yes	Yes
Stanislaus	-	-	-	-	Yes	Yes
Sutter	-	-	-	-	Yes	Yes
Tehama	-	-	Yes	-	Yes	Yes
Trinity	-	-	-	-	-	Yes
Tulare	-	-	-	-	-	-
Tuolumne	-	-	Yes	-	-	Yes
Ventura	-	-	-	-	Yes	Yes
Yolo	-	-	Yes	-	-	-
Yuba	-	-	-	-	Yes	Yes

Note:
Represents information as of August 2012.

Court Adjudication of Groundwater Rights

Another form of groundwater management in California is through the courts. When the groundwater resources do not meet water demands in an area, landowners may turn to the courts to determine how much groundwater can be rightfully extracted by each overlying landowner or appropriator. The court typically appoints a watermaster to administer the judgment and to periodically report to the court.

The inventory of adjudicated (court order, judgment, or decree) basins in California increased since the list was first published in Bulletin 118-2003. At the time *California's Groundwater Update 2013* was prepared, there were 24 groundwater adjudications in California, with the majority located in Southern California in the South Coast Hydrologic Region. Figure 2-22 shows the location and distribution of the adjudications and Table 2-15 lists each of the adjudications, the respective hydrologic region, groundwater basin name and numeric designation, county, judgment date, and watermaster.

The majority of groundwater adjudications in California impose extraction limits and/or management actions in the event of declining groundwater levels or degrading water quality. Groundwater adjudications are typically under the management of a court-appointed watermaster. It should be noted that the primary objective of a court-ordered adjudication is to provide a proportionate share of the available groundwater to the users within the basin so it can be extracted without having adverse effects to existing groundwater supplies. Because of the time-frame of many of the adjudications, groundwater dependent ecosystems and environmental consequences of groundwater extraction were not considered when these judgments were written.

Other Groundwater Management Planning Efforts

Groundwater management is also occurring through other avenues. IRWM incorporates the physical, environmental, societal, economic, legal, and jurisdictional aspects of water management into regional solutions through open and collaborative stakeholder process to promote sustainable water use. UWMPs incorporate long-term resource planning to meet existing and future water demands. AWMPs advance irrigation efficiency that benefits both farms and the environment.

Integrated Regional Water Management Plans

IRWM improves water management and supports economic stability, environmental stewardship, and public safety. IRWM plans involve multiple agencies, stakeholders, individuals, and groups, and cross jurisdictional, watershed, and political boundaries. The methods used in IRWM planning include developing water management strategies that relate to water supply and water quality, water use efficiency, operational flexibility, stewardship of land and natural resources, and groundwater resources. Statewide, the majority of IRWM plans address groundwater management in the form of goals, objectives, and strategies. They defer implementation of groundwater management and planning to local agencies through local GWMPs. Few IRWM plans actively manage groundwater. Efforts by IRWM regional water management groups may include creating groundwater contour maps for basin operations criteria, monitoring groundwater elevations, and monitoring groundwater quality.

Statewide, there are 48 IRWM plans that have been accepted by DWR. Figure 2-23 shows the locations and planning areas of the IRWM plans. The status of IRWM plans are discussed in Chapters 3 through 12 of this report. Additional information regarding IRWM planning can be found online at the DWR Web site: http://www.water.ca.gov/irwm/grants/index.cfm.

Figure 2-22 Location of Groundwater Adjudications in California

Table 2-15 Groundwater Adjudications in California

ID	Hydrologic Region	Court Judgment	Basin Number(s)	County	Judgment Date	Watermaster and/or Web site
A-1	South Coast, Colorado River	Beaumont Basin	7-21.04, 8-2.08	Riverside	2004	Beaumont Basin Watermaster
A-2	South Coast	Chino Basin	8-2.01	Riverside, San Bernardino	1978	Chino Basin Watermaster
A-3	South Coast	Cucamonga Basin	8-2.02	San Bernardino	1978	Not yet appointed; operated as a part of Chino Basin
A-4	South Coast	Central Basin	4-11.04	Los Angeles	1965	CA Department of Water Resources - Southern Region
A-5	South Coast	West Coast Basin	4-11.03	Los Angeles	1961	CA Department of Water Resources - Southern Region
A-6	Central Coast	Goleta Basin	3-16	Santa Barbara	1989	Goleta Water District
A-7	South Coast	Main San Gabriel Basin	4-13	Los Angeles	1973	Main San Gabriel Basin Watermaster
A-8	South Lahontan, Colorado River	Mojave Basin Area	7-19; 6-40, 6-41, 6-42, 6-43, 6-47, 6-37, 6-89	San Bernardino	1996	Mojave Water Agency
A-9	South Coast	Raymond Basin	4-23	Los Angeles	1944	Raymond Basin Management Board
A-10	South Coast	Western San Bernardino	8-2.06, 8-2.04, 8-2.03, 8-2.05	Riverside, San Bernardino	1969	Representatives from the San Bernardino Valley Municipal Water District and Western Municipal Water District
A-11	South Coast	Rialto-Colton	8-2.04	San Bernardino	1961	San Bernardino Valley Municipal Water District
A-12	South Coast	Santa Margarita River Watershed	9-06, 8-4, 8-05, 9-04, 9-05	Riverside and San Diego	1966	Santa Margarita River Watershed Watermaster
A-13	Central Coast	Santa Maria Valley Basin	9-11	Santa Barbara, San Luis Obispo	2008	The three management areas within the adjudicated boundary are managed by various entities.[a,b]

ID	Hydrologic Region	Court Judgment	Basin Number(s)	County	Judgment Date	Watermaster and/or Web site
A-14	South Coast	Santa Paula Basin	4-4.04	Ventura	1996	Technical Advisory Committee: United Water Conservation District, City of Ventura, Santa Paula Basin Pumpers Association
A-15	North Coast	Scott River Stream System	1-5	Siskiyou	1980	Scott and Shasta Valley Watermaster District
A-16	Central Coast	Seaside Basin	3-4.08	Monterey	2006	Seaside Groundwater Basin Watermaster
A-17	South Coast	Six Basins	4-13	Los Angeles, San Bernardino	1998	Six Basins Watermaster
A-18	Tulare Lake	Tehachapi Basin	6-45; 5-28	Kern	1971	Tehachapi-Cummings County Water District
A-19	Tulare Lake	Cummings Basin	5-27	Kern	1972	Tehachapi-Cummings County Water District
A-20	Tulare Lake	Brite Basin	5-80	Kern	1970	Tehachapi-Cummings County Water District
A-21	South Coast	Upper Los Angeles River Area	4-12	Los Angeles	1979	Upper Los Angeles River Area Watermaster
A-22	South Coast	Puente Basin	4-13	Los Angeles	1985	Walnut Valley Water District
A-23	Colorado River	Warren Valley Basin	7-12	San Bernardino	1977	Warren Valley Basin Watermaster
A-24	South Coast	San Jacinto	8-5	Riverside	2013	Hemet-San Jacinto Watermaster

Notes:

[a]Management areas: Santa Maria Valley, Nipomo Mesa, and northern cities.

[b]No watermaster is designated for the basin or management areas.

Data last updated in 2013.

Only adjudications that authorize the potential restriction of groundwater pumping, to ensure groundwater sustainability, within the boundaries of a particular groundwater basin are included on this list.

Urban Water Management Plans

UWMPs are prepared by California's urban water suppliers to support their long-term resource planning and to ensure adequate water supplies are available to meet existing and future water demands. UWMPs include system descriptions, demands, supplies, and water shortage reliability and water shortage contingency planning. In addition, the Water Conservation Bill of 2009 (SB X7-7) requires that urban water suppliers:

- Develop a single standardized water use reporting form for urban water suppliers.
- Develop method(s) by July 1, 2011 to identify per capita targets, and update those methods in four years to meet the 20 percent reduction goal by 2020.
- Develop technical methodologies and criteria for calculating all urban water use.
- Convene a task force to develop alternative best management practices for commercial, industrial, and institutional water use.

Urban use of groundwater is one of the few uses that meter and report annual groundwater extraction volumes. The groundwater extraction data is currently submitted with the UWMP and then manually translated by DWR staff into a database. Online methods for urban water managers to directly enter their water use along with their UWMP updates are being evaluated. Additional information regarding urban water management and UWMPs can be found at http://www.water.ca.gov/urbanwatermanagement/.

Agricultural Water Management Plans

AWMPs are developed by water and irrigation districts to advance the efficiency of farm water management while benefitting the environment. The AWMPs provide another avenue for local groundwater management. Some of the efficient water management practices currently being implemented include controlling drainage problems through alternative use of lands, using recycled water that otherwise would not be used beneficially, improvement of on-farm irrigation systems, and lining or piping ditches and canals. In addition, SB X7-7 requires that agricultural water suppliers perform the following:

- Report the status of AWMPs and efficient water management practices and evaluate their effectiveness.
- Adopt regulations to measure the volume of water delivered and for adopting a pricing structure based on quantity delivered.
- Develop a method for quantifying efficiency of agriculture water use and a plan for implementation.
- Propose new statewide targets for regional water management practices for recycled water, brackish groundwater, and stormwater runoff.
- Promote implementation of regional water management practices through increased incentives and removal of barriers.

New and updated AWMPs addressing the SB X7-7 requirements were required to be submitted to DWR by December 31, 2012 for review and approval. More information about AWMPs can be found at http://www.water.ca.gov/wateruseefficiency/agricultural/agmgmt.cfm.

Figure 2-23 Location of Integrated Regional Water Management Plans in California

Statewide Conjunctive Management Inventory

Conjunctive management, or conjunctive use, refers to the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various management objectives. Managing both resources together, rather than in isolation, allows water managers to use the advantages of both resources for maximum benefit.

Conjunctive management of surface water and groundwater has been utilized throughout California for decades to meet increasing water uses during surface water cutbacks, to mitigate declining groundwater levels, and help limit subsidence. To meet water uses throughout California, groundwater supply is supplemented by imported surface water from State, federal, and local water projects. Many local agencies have developed groundwater recharge facilities to capture peak stormwater runoff and to fully utilize imported surface water supplies.

As part of *California Water Plan Update 2013*, an inventory and assessment of conjunctive management programs in California was conducted. The overall intent of this effort was to: (1) provide a statewide summary of conjunctive water management program locations, operational methods, and capacities; and (2) identify their challenges, successes, and opportunities for growth to share with policy makers and other stakeholders to enable an informed decision making process regarding groundwater and its management. Additional information regarding conjunctive management in California, as well as a discussion on associated benefits, costs, and issues, can be found online from *California Water Plan Update 2013*, Volume 3, Chapter 9, "Conjunctive Management and Groundwater Storage."

The statewide conjunctive management inventory and assessment consisted of literature research, an online survey, personal communication with local agencies, and a documented summary of the conjunctive management programs in California. Information from these efforts was compiled into a comprehensive spreadsheet of projects and historic operational information, which was updated and enhanced with data from a coordinated DWR/ACWA survey.

The online survey administered by ACWA requested the following conjunctive management program information from its member agencies:

1. Location of conjunctive use project.
2. Year project was developed.
3. Capital cost to develop the project.
4. Annual operating cost of the project.
5. Administrator/operator of the project.
6. Capacity of the project in units of acre-feet.

Although initial response to the survey was encouraging, the number of survey participants and the completeness of those responses were limited. In an attempt to build upon the ACWA survey and develop a greater understanding of the size and diversity of conjunctive management projects in California, DWR's four regional offices contacted, either by telephone or through email, each

Table 2-16 Number of Reported Conjunctive Management Agencies by Hydrologic Region

Hydrologic Region	Number of Active Conjunctive Management Programs
North Coast	0
San Francisco Bay	4
Central Coast	5
South Coast	32
Sacramento River	3
San Joaquin River	5
Tulare Lake	37
North Lahontan	0
South Lahontan	2
Colorado River	1
Total	**89**

Note:
Data reflects active conjunctive management agencies identified by DWR as of July 2012 and may not represent all conjunctive management agencies in California.

of the entities identified as having a conjunctive water management program. DWR's follow-up efforts requested additional details regarding:

- Source of water received.
- Put and take capacity of the groundwater bank or conjunctive use project.
- Type of groundwater bank or conjunctive use project.
- Program goals and objectives.
- Constraints on development of conjunctive management or groundwater banking (recharge) program.

Statewide Conjunctive Management Inventory Results

Statewide, a total of 89 conjunctive management and groundwater recharge programs were identified. Because of confidentiality concerns expressed by some local agencies, information for some existing conjunctive management programs was not reported. Also, conjunctive management and groundwater recharge programs that were in the planning and feasibility stage were not included in the inventory. A series of tables listing all of the conjunctive management projects identified by DWR, grouped by hydrologic region, and information specific to the 11 questions noted above, is provided in Appendix D of this report.

Location of Conjunctive Management Project

The majority of California's conjunctive management projects are located in the Tulare Lake and South Coast hydrologic regions; few active projects are operated in Northern California and along the east side of the Sierra Nevada. A summary of the number of agencies, or collaborative conjunctive management programs, in each hydrologic region is provided in Table 2-16. A map showing the statewide locations of the agencies conducting conjunctive management or groundwater recharge operations is shown in Figure 2-24. The locations shown in Figure 2-24 do not indicate the locations of the actual groundwater recharge projects, rather the locations of the implementing agencies' offices. The conjunctive management survey asked agencies to identify the groundwater basin that their program was located in, but only 46 percent of the programs provided that data.

Year Project Was Developed

Based on the survey results, with 31 of the 89 known agencies or programs reporting, the earliest reported conjunctive use project was initiated in 1912 by the San Bernardino Valley Water Conservation District, located in the South Coast Hydrologic Region. Although the majority of the surveyed agencies did not indicate when their conjunctive management program was developed, based on the data received, most of the programs were developed in the 1990s and 2000s. This coincides with the enactment of the Groundwater Management Act (AB 3030) in 1992 and the approval of Proposition 13 in 2000, which funded DWR's groundwater storage and conjunctive use grants and loans program. Figure 2-25 shows the number of conjunctive management projects developed per decade, based on the information reported by 31 agencies.

Capital Cost to Develop the Project

Details about the capital cost to develop a local conjunctive management program were provided by 17 of the 89 agencies. Based on the responses provided, the largest regional investment in conjunctive management and groundwater recharge projects occurred in the South Coast Hydrologic Region. However, the survey details are incomplete, as only two of the 37 programs in the Tulare Lake Hydrologic Region reported data. According to the survey responses, the greatest capital cost to develop a conjunctive management project was reported to be more than $100 million by the Inland Empire Utilities District.

Annual Operating Cost of the Project

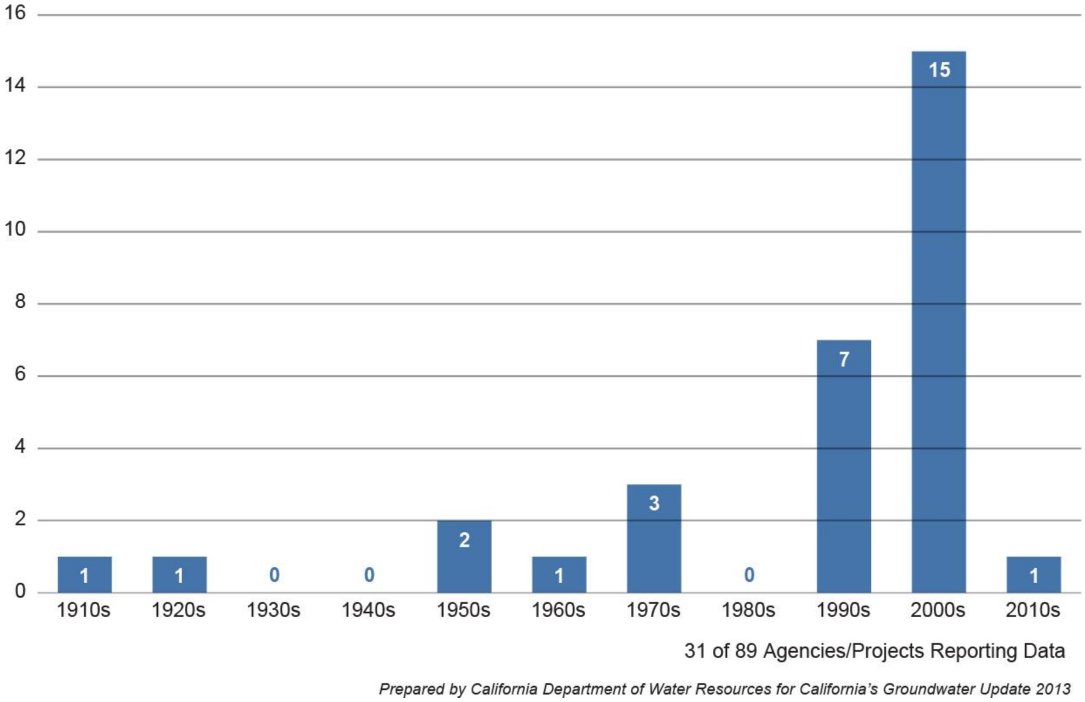
Details about the annual operating cost of local conjunctive management programs were provided by 19 of the 89 agencies. As indicated by the survey results, the units of operating cost varied among the agencies that provided information. Some agencies reported annual operating costs in dollars per year, while other agencies reported operating costs in dollars per acre-feet, making direct comparison between multiple projects or agencies difficult. Using dollar amounts, the largest annual operating cost ($3 million) is incurred by the Santa Clara Valley Water District, while the smallest annual operating cost ($30,000) is incurred by the Tehachapi-Cummings County Water District.

Administrator/Operator of the Project

Based on the information reported in the survey, the administrator/operator of a conjunctive management project is generally the lead agency of the project.

Figure 2-24 Locations of Agencies in California that Operate Conjunctive Management Programs

Figure 2-25 Number of Conjunctive Management Projects Developed per Decade in California



Capacity of the Project in Units of Acre-Feet

Quantitative details about the capacity of local conjunctive management programs were provided by 34 of the 89 agencies. Some of the reported volumes are actual capacities, while other reported values represent estimated capacities. The largest reported conjunctive management program, based on total storage capacity, was Semitropic Water Storage District, with a storage capacity of 2.1 million acre-feet. The smallest storage capacity project, at 2,289 acre-feet, was reported by the Compton Water Department.

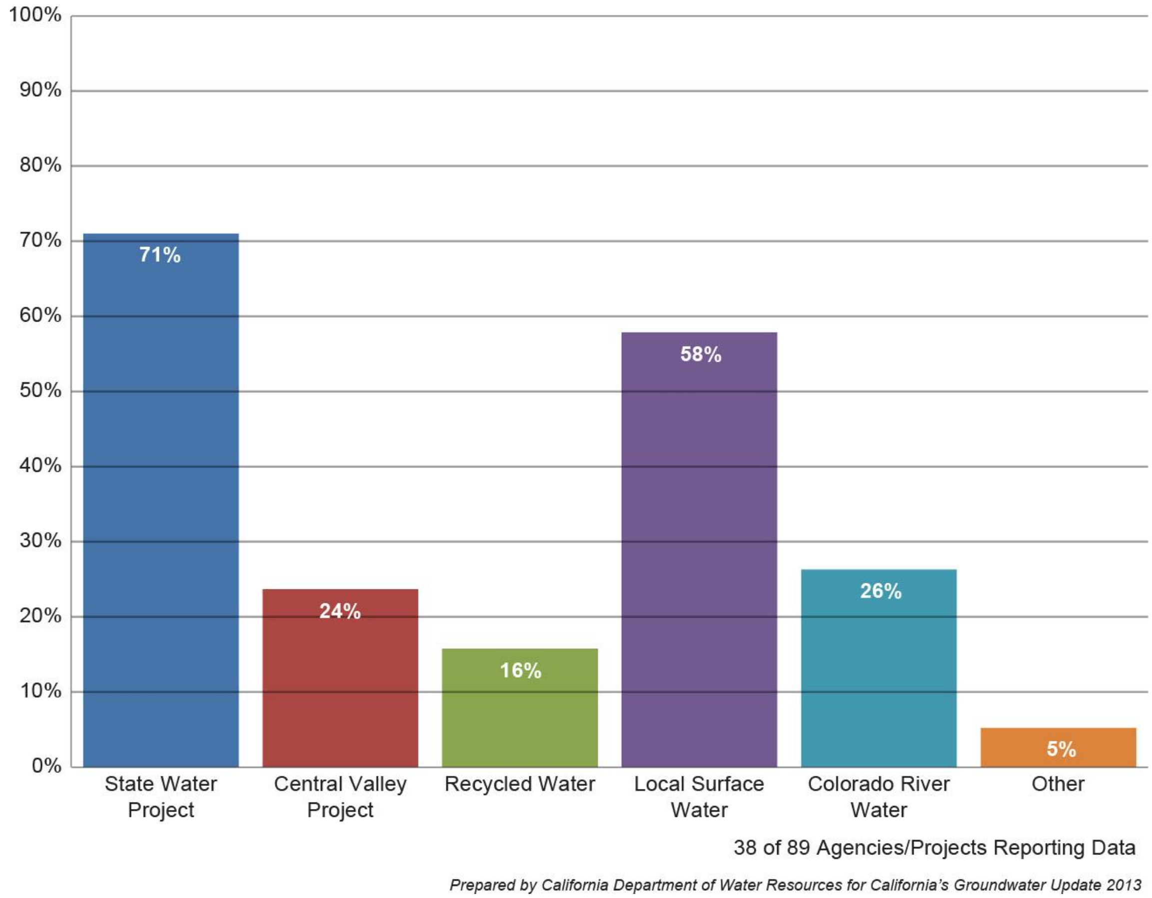
Source of Water Received

Details describing the sources of water received for use in active conjunctive management programs were provided by 38 of the 89 agencies. Of the agencies responding to the survey, as shown in Figure 2-26, 71percent of the survey respondents managed water that originated from the State Water Project, 58 percent used local surface water, 26 percent operated their programs with Colorado River water, 24 percent used water from the Central Valley Project, 16 percent used recycled water, and 5 percent used water from “other” sources, which included the South Bay Aqueduct and a raw water source from San Diego County Water Authority. As shown in the survey results, most agencies used water from more than one source.

Put and Take Capacity of Project

Details about the put (recharge) and take (extraction) capacity of conjunctive management programs were provided by 48 of the 89 agencies. DWR requested that agencies report: (1) how much water is annually recharged; (2) how much water has cumulatively been recharged; (3) how much groundwater is annually withdrawn from the recharged aquifer; (4) how much groundwater

Figure 2-26 Sources of Water Used for Conjunctive Management Programs in California

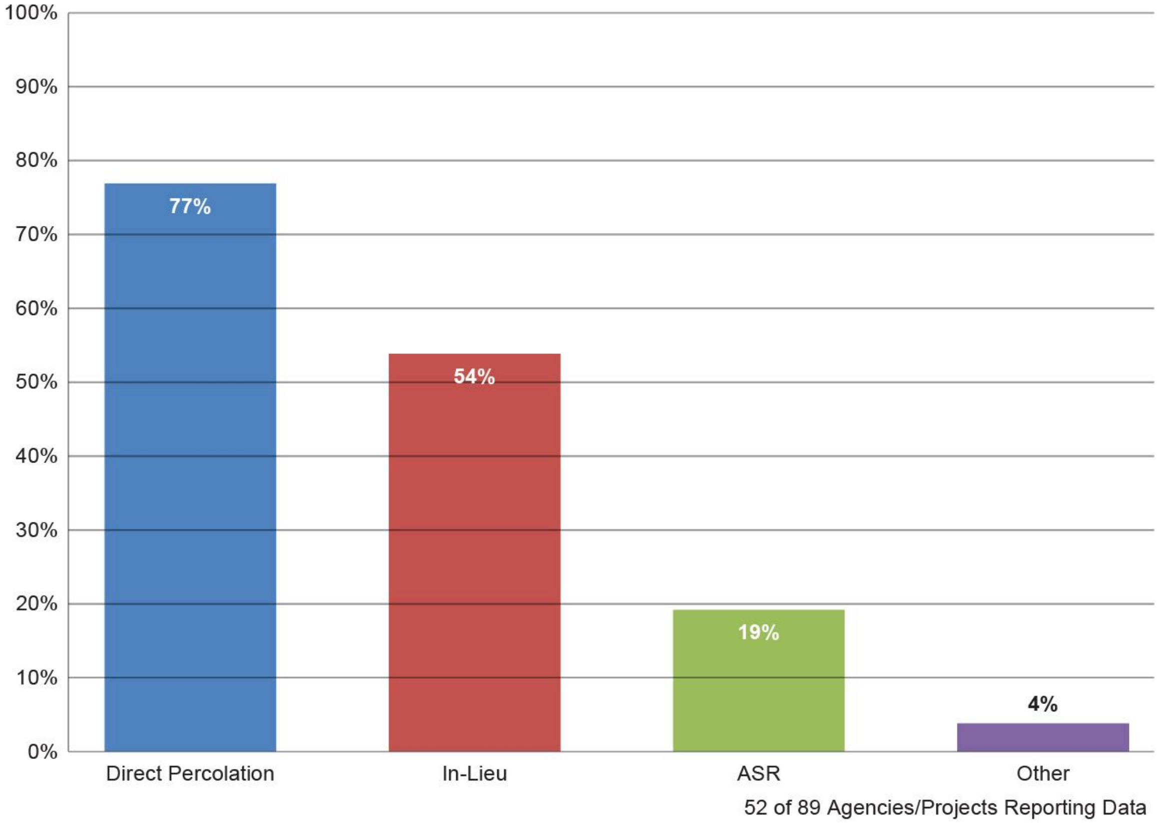


has cumulatively been withdrawn from the recharged aquifer; and (5) what is a normal or average dry-year take. Of the 48 agencies providing some recharge and extraction data for their conjunctive use program, only 13 agencies provided details for annual and cumulative put, and annual and cumulative take; however, few of those agencies reported data for dry year take. Thus, the reported dataset for recharge and extraction volumes is incomplete in the survey table. Project- and agency-specific details are provided in Appendix D.

Type of Groundwater Bank or Conjunctive Management Project

Details about the methods used for groundwater recharge were provided by 52 of the 89 agencies. As shown in Figure 2-27, 77 percent managed spreading basins, 52 percent operated in-lieu recharge programs, 19 percent used injection/extraction wells or aquifer storage and recovery methods, and 4 percent used other methods. The other methods included the use of injection-only wells to establish a seawater intrusion barrier by the Water Replenishment District of Southern California and injection-only wells by Foothill Municipal Water District. As shown in the survey results table, most agencies operated conjunctive management programs using more than one groundwater recharge methods.

Figure 2-27 Method Used for Groundwater Recharge in a Conjunctive Management Program



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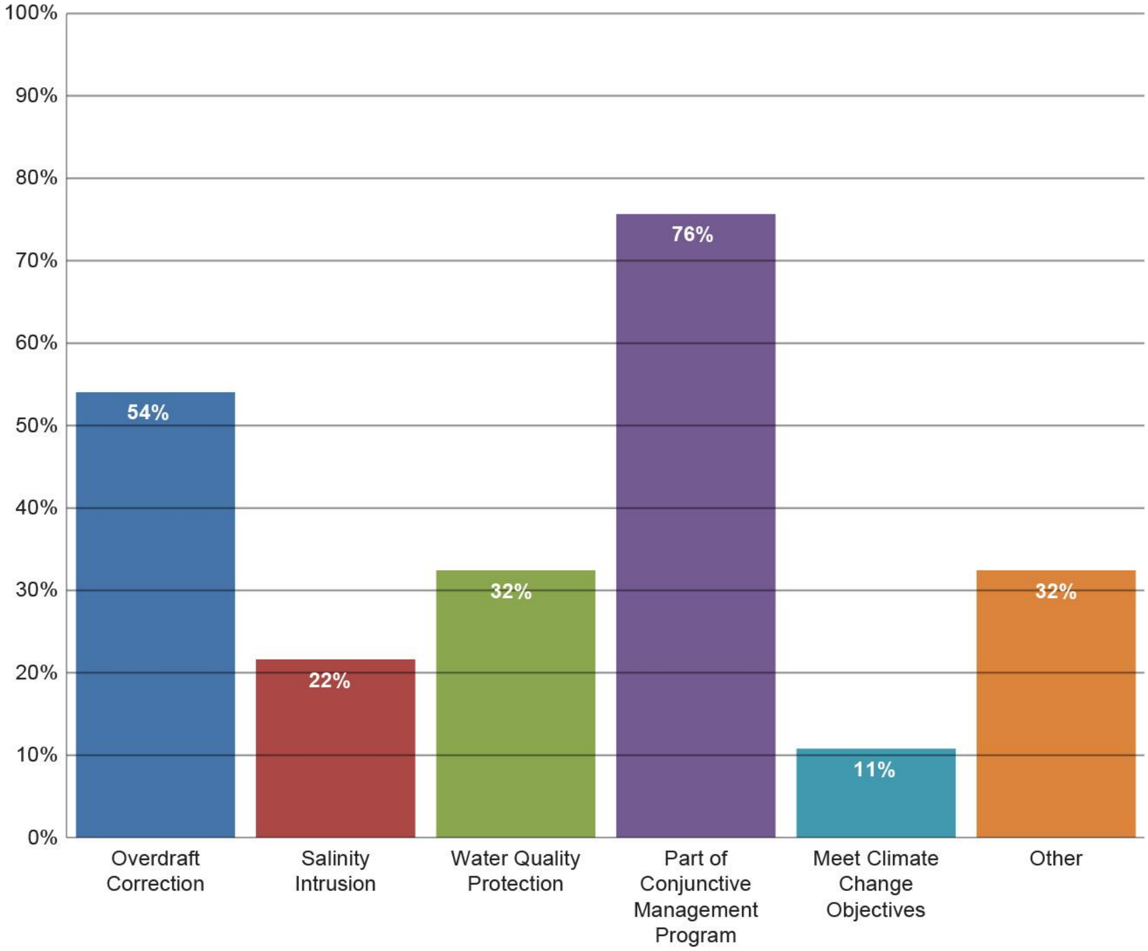
Program Goals and Objectives

Details about the goals and objectives of local conjunctive management programs were provided by 37 of the 89 agencies. Most respondents included multiple goals and objectives. As shown in Figure 2-28, other than being part of a conjunctive management program (78 percent of respondents), 54 percent of respondents indicated that a conjunctive management program was operated by their agency to address local groundwater overdraft conditions. In addition to correcting overdraft, 32 percent of respondents operated a program to address water quality, 22 percent had goals to prevent or halt salinity intrusion, 11 percent needed to meet climate change objectives, and 33 percent indicated other goals and objectives for their conjunctive management programs. Some of the other goals and objectives include: complying with regulations, meeting direct delivery demands during a single dry year, emergency storage, sustainable supply, flood management, cost reduction, and drought planning.

Figure 2-28 Reported Goals and Objectives for Conjunctive Management Programs in California



37 of 89 Agencies/Projects Reporting Data

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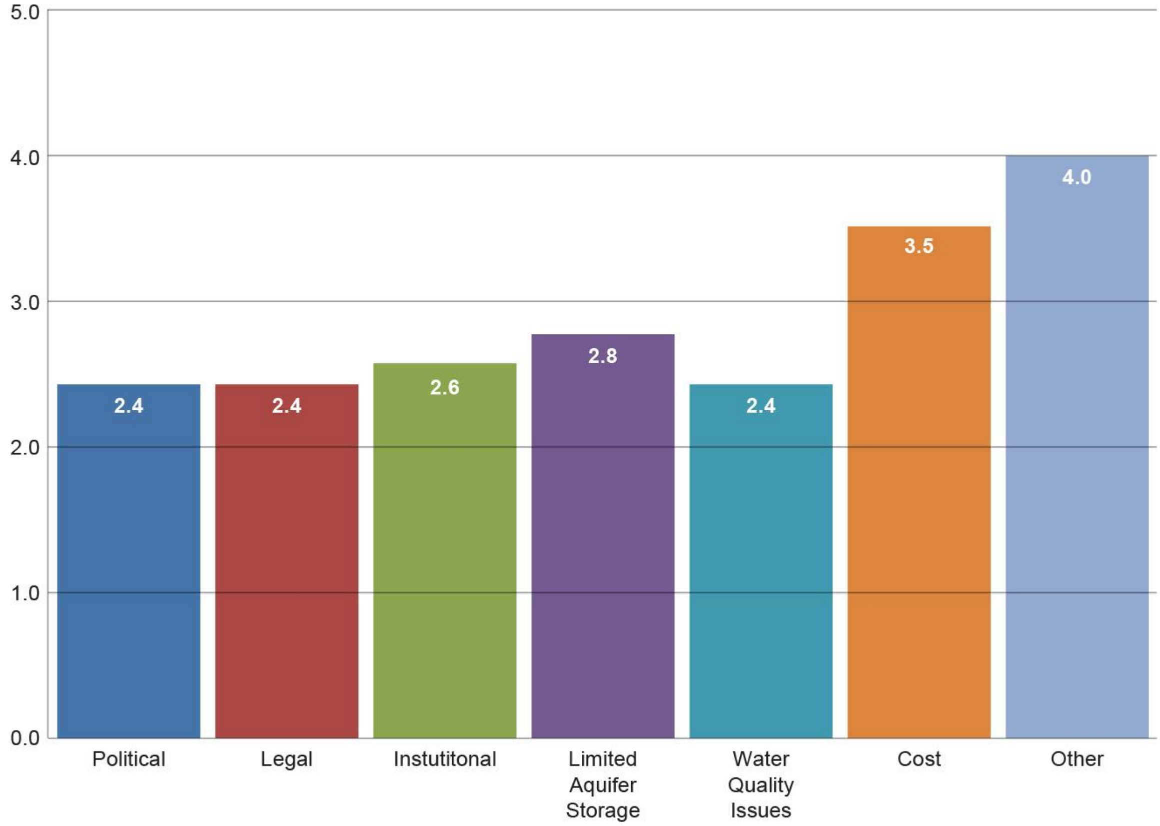
Constraints on Development of Conjunctive Management or Groundwater Banking Program

Details about constraints on developing local conjunctive management programs were provided by 25 of the 89 agencies. Respondents were asked to rank the following operational constraint categories: political, legal, institutional, limited aquifer storage, water quality issues, cost, and other. The ranking system used a "1" for minimal constraint, a "3" for moderate constraint, or a "5" for significant constraint. The average ranking of the seven categories is shown in Figure 2-29. The high cost of conjunctive management programs was indicated to be the greatest single constraint, ranking 3.5 out of 5. Some of the other constraints, which were often seen as a more significant constraint by four of the reporting agencies, ranking 4 out of 5, include the following issues: economy, complex geology, environmental considerations, and regulatory requirements.

Figure 2-29 Reported Constraints on Conjunctive Management Program Development in California



25 of 89 Agencies/Projects Reporting Data

Rank: 1 = minimal constraint 3 = moderate constraint 5 = significant constraint

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