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
Department of Water Resources

SOUTH LAHONTAN HYDROLOGIC REGION

Contents

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Acronyms and Abbreviations Used in This Chapter

AB	Assembly Bill
ACWA	Association of California Water Agencies
AVEK	Antelope Valley-East Kern Water Agency
AWMP	agricultural water management plan
bgs	below ground surface
BMO	basin management objective
CASGEM	California Statewide Groundwater Elevation Monitoring
CDPH	California Department of Public Health
CWP	California Water Plan
CWS	community water system
DAU	detailed analysis unit
DWR	California Department of Water Resources
FPA	free production allowance
GAMA	Groundwater Ambient Monitoring and Assessment
gpm	gallons per minute
GPS	global positioning system
GWMP	groundwater management plan
HAL	health advisory level
IRWM	integrated regional water management
LAA	Los Angeles Aqueduct
LLNL	Lawrence Livermore National Laboratory
NL	notification level

MCL	maximum contaminant level
MWA	Mojave Water Agency
PA	Planning Area
ppb	parts per billion
RWMG	regional water management group
RWQCB	regional water quality control board
SB	Senate Bill
SB X7-6	2009 Comprehensive Water Package legislation
SB X7-7	Water Conservation Bill of 2009
SNMP	salt and nutrient management plan
SMCL	secondary maximum contaminant level
South Lahontan region	South Lahontan Hydrologic Region
SWN	State Well Number
SWP	State Water Project
SWRCB	State Water Resources Control Board
taf	thousand acre-feet
TDS	total dissolved solids
USGS	U.S. Geological Survey
UWMP	urban water management plan

Chapter 11. South Lahontan Hydrologic Region Groundwater Update

Introduction

The primary goal of the South Lahontan Hydrologic Region (South Lahontan region) groundwater update is to expand information about region-specific groundwater conditions for *California Water Plan Update 2013*, and to guide more informed groundwater management actions and policies. A second goal is to steadily improve the quality of groundwater information in future California Water Plan (CWP) updates to a level that will enable regional water management groups (RWMGs) to accurately evaluate their groundwater resources and implement management strategies that can meet local and regional water resource objectives within the context of broader statewide objectives. The final goal is to identify data gaps and groundwater management challenges that will guide prioritizing of future data collection and funding opportunities relevant to the region.

This regional groundwater update is not intended to provide a comprehensive and detailed examination of local groundwater conditions, or be a substitute for local studies and analysis. Nonetheless, where information is readily available, this update does report some aspects of the regional groundwater conditions in greater detail.

The South Lahontan region (Figure 11-1) covers about 26,700 square miles. It includes all of Inyo County and portions of Mono, San Bernardino, Kern, and Los Angeles counties. Significant geographic features include the White, Inyo, and Panamint mountain ranges; Antelope, Owens, Panamint, and Death valleys; the Mojave Desert, Mono Lake, and the Long Valley Caldera. The South Lahontan region includes Mount Whitney and Death Valley, the highest and lowest ground surface elevations, respectively, in the contiguous United States. Major waterways include the Owens, Mojave, and Amargosa rivers, and the Mono Lake drainage system.

The region has an arid to semi-arid climate, an average annual precipitation of 7.9 inches, and an average annual runoff of 1.3 million acre-feet. Information from the 2010 census indicates an overall population of approximately 931,000, with more than 90 percent living in Antelope Valley and in areas overlying the groundwater basins adjacent to the Mojave River. Most of the region is unpopulated.

The groundwater update for the South Lahontan region provides an overview and assessment of the region's groundwater supply and development, groundwater use, monitoring efforts, aquifer conditions, and various management activities. It also identifies challenges and opportunities associated with sustainable groundwater management. The regional update starts with a summary of findings, examines groundwater data gaps, and makes recommendations to further improve the overall sustainability of groundwater resources. This is followed by a comprehensive overview of the relevant groundwater topics.

Figure 11-1 South Lahontan Hydrologic Region

Findings, Data Gaps, and Recommendations

The following information is specific to the South Lahontan region and summarizes the findings, data gaps, and recommendations.

Findings

The bulleted items presented in this section are adopted from more comprehensive information presented in this chapter and generally reflect information that was readily available through August 2012. Much of the groundwater information, including well infrastructure discussions, water supply analysis, and groundwater management plan (GWMP) reviews, is new to this update of the CWP. The groundwater data presented in this chapter will be used as the foundation for the next update of California Department of Water Resources (DWR) Bulletin 118 and the CWP, with the goal of generating information that can be used to make informed decisions to sustainably manage California's groundwater resources. The following information highlights the groundwater findings for the South Lahontan region.

Groundwater Supply and Development

- The South Lahontan region contains 77 alluvial groundwater basins and subbasins recognized by DWR Bulletin 118-2003. Those groundwater basins and subbasins underlie approximately 14,800 square miles, or 55 percent, of the hydrologic region (Figure 11-2 and Table 11-1).
- Based on DWR well-log records, the number of wells completed in the South Lahontan region between 1977 and 2010 is approximately 13,112, which includes 10,934 wells for San Bernardino County; 1,131 wells for Inyo County; and 1,047 wells for Mono County (Figure 11-3 and Table 11-2).
- Based on the California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization completed in December 2013, two basins in the South Lahontan region are identified as high priority, three basins are identified as medium priority, seven basins are listed as low priority, and the remaining 65 basins are listed as very low priority. The five basins designated as high or medium priority include 55 percent of the annual groundwater use and nearly 94 percent of the 2010 population living within the region's groundwater basin boundaries (Figure 11-6 and Table 11-3).

Groundwater Use and Aquifer Conditions

- The 2005-2010 average annual total water supply for the South Lahontan region, based on planning area boundaries, is estimated at 668 thousand acre-feet (taf). Water demands in the region are met through a combination of local and imported surface-water sources, State (State Water Project [SWP]) surface-water deliveries, groundwater, and reused/recycled water supplies (Figure 11-7).
- Groundwater contributes about 66 percent (441 taf) of the 2005-2010 average annual total water supply for the South Lahontan region (Figure 11-7, Table 11-4).
- Groundwater supplies, based on average annual estimates for 2005-2010, contribute 72 percent of the total agricultural water supply and 58 percent of the total urban water supply. No groundwater is applied to managed wetlands in the South Lahontan region (Table 11-4).

- Between 2002 and 2010, annual groundwater use in the South Lahontan region ranged between 384 taf in 2005 and 491 taf in 2008, and contributed between 60 percent and 71 percent toward the annual water supply (Figure 11-8).
- Of the groundwater pumped on an annual basis between 2002 and 2010, 59 percent to 68 percent of the groundwater was used for agricultural purposes (Figure 11-9).

Groundwater Monitoring Efforts

- In the South Lahontan region, 1,066 wells are actively monitored for groundwater-level information (Figure 11-10 and Table 11-7).
- There are an estimated 185 community water systems (CWSs) in the South Lahontan region with an estimated 636 active CWS wells; 180 of the CWS wells (28 percent) are identified as being affected by one or more chemical contaminants that exceed a maximum contaminant level (MCL). The affected wells are used by 73 CWSs in the region, with the majority of the affected CWSs serving small communities. The most prevalent groundwater contaminants affecting community drinking water wells in the region include arsenic, gross alpha particle activity, uranium, and fluoride. In addition, 46 regional wells are affected by multiple contaminants (Tables 11-10, 11-11, and 11-12).
- In the South Lahontan region, researchers have investigated the occurrence of land subsidence in the Mojave Desert and at two locations in the Antelope Valley. In the Antelope Valley Basin, more than 6 feet of land subsidence occurred in the area around Lancaster as a result of a groundwater-level decline of more than 200 feet since the 1920s. A second occurrence of land subsidence within the Antelope Valley Basin was investigated at Edwards Air Force Base, where long-term groundwater extractions resulted in nearly 4 feet of land subsidence between 1926 and 1992. Between 1990 and 2000, almost 0.4 foot of subsidence occurred. Subsidence ranging from 0.15 foot to 0.3 foot occurred in four areas of the Mojave Desert. Details are available in the "Land Subsidence" section of this chapter and Appendix F.

Groundwater Management and Conjunctive Management

- There are four GWMPs within the South Lahontan region that collectively cover about 28 percent of the Bulletin 118-2003 alluvial basin area within the region and about 19 percent of the overall region.
- DWR's assessment of GWMPs in the South Lahontan region determined that three of the four GWMPs have been developed or updated to include the legislative requirements of Senate Bill (SB) 1938 and are considered "active" for the purposes of the GWMP assessment. One GWMP in the region addresses all of the required components identified in California Water Code Section10753.7 (Figure 11-12 and Table 11-14).
- Of the 89 agencies or programs identified as operating a conjunctive management or groundwater recharge program in California, two programs are located in the South Lahontan region. The Mojave Water Agency (MWA) and the Antelope Valley-East Kern Water Agency (AVEK) operate conjunctive management programs in the South Lahontan region. The effort to fully characterize the 89 conjunctive management programs, as part of the *California Water Plan Update 2013*, was largely unsuccessful

as numerous agencies were reluctant to make details about their groundwater recharge operations publically available (Appendix D).

Data Gaps

Gaps in groundwater information are separated into three categories: data collection and analysis, basin assessments, and sustainable management. Where possible, the discussion of data gaps is specific to the South Lahontan region. But many of the identified gaps are applicable to several or all hydrologic regions in California. Addressing these data gaps at both the local level and State agency level will help ensure that groundwater resources throughout California are better characterized and sustainably managed.

Data Collection and Analysis

Although the general characterization of some alluvial aquifer systems in the South Lahontan region is satisfactory, there is a need to further improve the characterization of many of the region's aquifers, especially those aquifers that serve disadvantaged communities. More data is always necessary to better understand basin-wide and region-wide groundwater levels, groundwater quality, groundwater use, and the interaction between surface water and groundwater.

Information related to groundwater extraction, groundwater use, managed and natural recharge, and groundwater basin budgets in the South Lahontan region is extremely limited. Much of the related information has been estimated primarily through water supply balance and land use information derived from DWR's land use surveys. Little or no information is known, or is publically available, about the fractured-bedrock aquifers in the South Lahontan region and how they interact with the region's alluvial aquifer systems.

Some local water agencies in the South Lahontan region are collecting appropriate groundwater data, conducting necessary analyses, and are sustainably managing their basins by using their existing authorities. But locally collected and analyzed data, which could be used by RWMGs and State agencies to better characterize the groundwater basins in the South Lahontan region, are generally not readily available.

Basin Assessments

Region-wide depth-to-groundwater information and annual estimates of change in groundwater in storage are not well understood for all of the groundwater basins in the South Lahontan region.

Information related to groundwater quality in the South Lahontan region is variable. The Groundwater Ambient Monitoring and Assessment (GAMA) Domestic Well Project has not sampled private domestic wells in the five counties that are part of the South Lahontan region. Throughout the South Lahontan region, participating in the development of the salt and nutrient management plan is of paramount importance to improve water quality in the region.

Researchers have investigated the occurrence of land subsidence in the Mojave Desert and at two locations in Antelope Valley, though land subsidence may be occurring in other areas of the region. The MWA recognizes the potential for future land subsidence and has developed water management objectives to reduce the potential for land subsidence. The population growth in Antelope Valley is expected to continue and the forecasted water demand is expected to exceed available water supplies. Land subsidence has been occurring in the Antelope Valley since the 1950s and will likely continue if groundwater levels continue to decline.

There are two groundwater recharge or conjunctive use projects in the South Lahontan region that were identified as part of the statewide conjunctive management survey, but some additional projects may be in the planning or feasibility stage. The survey conducted as part of *California Water Plan Update 2013* was unable to collect comprehensive information about many statewide programs. As a result, a general understanding of the effectiveness of the State's groundwater recharge and conjunctive management programs could not be determined. In addition, it is unknown whether local agencies have complied with the groundwater recharge mapping requirements of Assembly Bill (AB) 359, which went into effect on January 1, 2013.

Sustainable Management

The three active GWMPs in the South Lahontan region that meet some or all of the SB 1938 groundwater management requirements cover 22 percent of the alluvial groundwater basin area. A key gap to implementing sustainable groundwater management practices at the local level is the limited authority of some agencies to assess management fees, restrict groundwater extraction, and regulate land use in groundwater short areas.

Recommendations

While much information is known about some of the groundwater basins in the South Lahontan region, comprehensive information that could provide a realistic water budget to determine groundwater sustainability in the region is largely unknown. To better characterize and sustainably manage the region's groundwater resources, the following recommendations are made for the South Lahontan region:

- Increase collection and analysis of groundwater level, quality, use, and extraction data, as well as information regarding the surface-water–groundwater interaction in alluvial aquifers, to a level that allows for development of groundwater budgets, groundwater supply forecasting, and assessment of sustainable groundwater management practices.
- Increase data collection in fractured-bedrock aquifers to determine the degree of interaction that the upland areas have with the region's alluvial aquifers.
- Establish land-subsidence monitoring in areas of high groundwater use to quantify the potential permanent loss of groundwater storage throughout the region that has been caused by excessive local groundwater pumping.
- Continue to monitor groundwater quality throughout the region to better determine sources of natural and anthropogenic contamination, and comply with all groundwater quality protection strategies recommended by the Lahontan Regional Water Quality Control Board.
- Update all existing GWMPs to meet the standards set forth in California Water Code Section10750 et seq. and ensure that GWMPs are prepared for all medium-priority groundwater basins as identified by the CASGEM Basin Prioritization process.
- Determine the extent and effectiveness of any new or proposed groundwater recharge or conjunctive management programs in the South Lahontan region. To achieve this,

DWR should work with local water managers to complete the conjunctive management survey information and ensure that the groundwater recharge mapping requirements of AB 359 are met.

- Ensure local agency goals, actions, and plans for sustainable groundwater management are compatible with, and meet a minimum set of goals and actions established by, the overlying integrated regional water management (IRWM) plan.
- Provide local and regional agencies with the authority to assess fees, limit groundwater extraction, and restrict land use in groundwater-short areas as needed, to better establish a path toward sustainable groundwater management.
- Develop annual groundwater management reports that summarize groundwater management goals, objectives, performance measures, current and projected trends for groundwater extraction, groundwater levels, groundwater quality, land subsidence, and surface-water–groundwater interaction. Annual reports should evaluate how existing groundwater management practices contribute toward sustainable groundwater management. They should also identify proposed actions for improvements.

Groundwater Supply and Development

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

Groundwater resources in the South Lahontan region are supplied by alluvial aquifers and by fractured-rock aquifers. Alluvial aquifers are comprised of sand and gravel or finer-grained sediments, with groundwater stored within the voids, or pore space, between the alluvial sediments. Fractured-rock aquifers consist of impermeable metamorphic, volcanic, and hard sedimentary rocks, with groundwater stored within cracks, fractures, or other void spaces. The distribution and extent of the alluvial and fractured-rock aquifers, and the location of well development, varies significantly within the South Lahontan region. A brief description of the alluvial and fractured-rock aquifers for the region is provided in the following paragraphs. Additional information regarding alluvial and fractured-rock aquifers is available online from DWR Bulletin 118-2003 (http://www.water.ca.gov/groundwater/bulletin118/index.cfm).

Alluvial Aquifers

The South Lahontan region contains 77 alluvial groundwater basins and subbasins recognized by DWR Bulletin 118-2003. The groundwater basins and subbasins underlie approximately 14,800 square miles, or 55 percent, of the hydrologic region. Most of the groundwater in the South Lahontan region is stored in alluvial aquifers. A detailed description of aquifers within this region is beyond the scope of this report. This section includes a brief summary of the major groundwater basins and aquifers within the South Lahontan region. Additional information regarding groundwater basins in this hydrologic region may be obtained online from DWR Bulletin 118-2003 or DWR Bulletin 118 Groundwater Basin Maps and Descriptions (http://www.water.ca.gov/groundwater/bulletin118/gwbasins.cfm). Figure 11-2 shows the locations of the alluvial groundwater basins and subbasins in the region. Table 11-1 lists the names and numbers associated with the alluvial groundwater basins and subbasins.

Figure 11-2 **Alluvial Groundwater Basins and Subbasins in the South Lahontan Hydrologic Region**

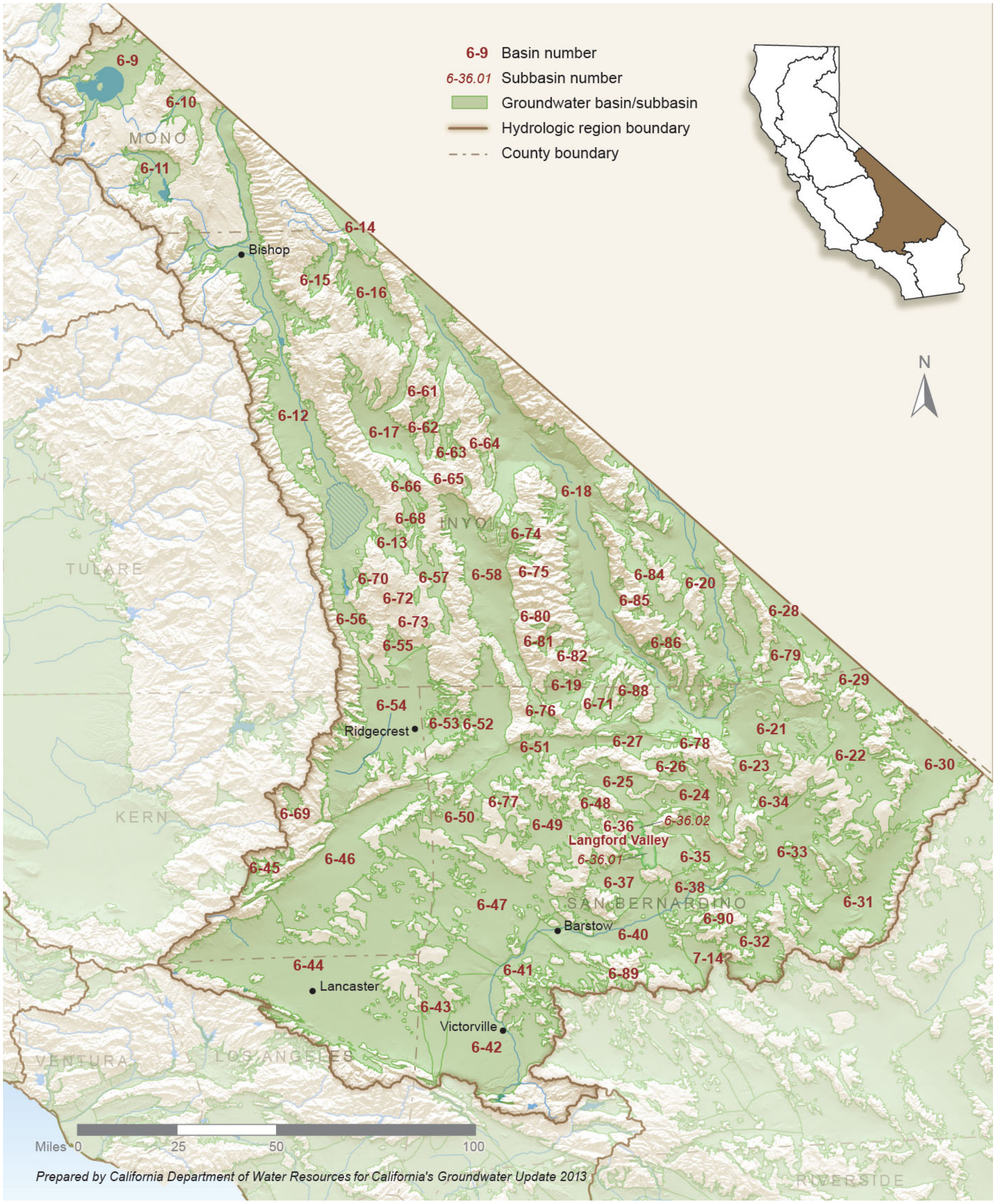


Table 11-1 Alluvial Groundwater Basins and Subbasins in the South Lahontan Hydrologic Region

Basin/Subbasin	Basin Name	Basin/Subbasin	Basin Name
6-9	Mono Valley	6-47	Harper Valley
6-10	Adobe Lake Valley	6-48	Goldstone Valley
6-11	Long Valley	6-49	Superior Valley
6-12	Owens Valley	6-50	Cuddeback Valley
6-13	Black Springs Valley	6-51	Pilot Knob Valley
6-14	Fish Lake Valley	6-52	Searles Valley
6-15	Deep Springs Valley	6-53	Salt Wells Valley
6-16	Eureka Valley	6-54	Indian Wells Valley
6-17	Saline Valley	6-55	Coso Valley
6-18	Death Valley	6-56	Rose Valley
6-19	Wingate Valley	6-57	Darwin Valley
6-20	Middle Amargosa Valley	6-58	Panamint Valley
6-21	Lower Kingston Valley	6-61	Cameo Area
6-22	Upper Kingston Valley	6-62	Race Track Valley
6-23	Riggs Valley	6-63	Hidden Valley
6-24	Red Pass Valley	6-64	Marble Canyon Area
6-25	Bicycle Valley	6-65	Cottonwood Spring Area
6-26	Avawatz Valley	6-66	Lee Flat
6-27	Leach Valley	6-68	Santa Rosa Flat
6-28	Pahrump Valley	6-69	Kelso Lander Valley
6-29	Mesquite Valley	6-70	Cactus Flat
6-30	Ivanpah Valley	6-71	Lost Lake Valley
6-31	Kelso Valley	6-72	Coles Flat
6-32	Broadwell Valley	6-73	Wild Horse Mesa Area
6-33	Soda Lake Valley	6-74	Harrisburg Flats
6-34	Silver Lake Valley	6-75	Wildrose Canyon
6-35	Cronise Valley	6-76	Brown Mountain Valley
6-36	Langford Valley	6-77	Grass Valley
6-36.01	Langford Well Lake	6-78	Denning Spring Valley
6-36.02	Irwin	6-79	California Valley
6-37	Coyote Lake Valley	6-80	Middle Park Canyon
6-38	Caves Canyon Valley	6-81	Butte Valley
6-40	Lower Mojave River Valley	6-82	Spring Canyon Valley
6-41	Middle Mojave River Valley	6-84	Greenwater Valley
6-42	Upper Mojave River Valley	6-85	Gold Valley
6-43	El Mirage Valley	6-86	Rhodes Hill Area
6-44	Antelope Valley	6-88	Owl Lake Valley
6-45	Tehachapi Valley East	6-89	Kane Wash Area
6-46	Fremont Valley	6-90	Cady Fault Area

Groundwater extracted by wells located outside of the alluvial basins is supplied largely from fractured-rock aquifers. In some cases, groundwater stored within a thin overlying layer of alluvial deposits or a thick soil horizon may also contribute to a well's groundwater supply.

The groundwater basins in the South Lahontan region with the greatest groundwater extraction include Antelope Valley Groundwater Basin; Fremont Valley Groundwater Basin; Owens Valley Groundwater Basin; Indian Wells Valley Groundwater Basin; and the Upper, Middle, and Lower Mojave River Valley groundwater basins. Because of heavy groundwater use and declining groundwater levels, groundwater in the Mojave Groundwater Basin area was adjudicated in 1996. MWA is the appointed watermaster to ensure that groundwater extraction in the Mojave Groundwater Basin area follows the terms of the adjudication.

Antelope Valley Groundwater Basin

The Antelope Valley Groundwater Basin (6-44) underlies a valley in the southwestern part of the region. The basin is bounded by the Garlock fault zone and the Tehachapi Mountains to the northwest, and the San Andreas fault zone and the San Gabriel Mountains to the southwest. El Mirage Valley and Harper Valley are to the east of Antelope Valley, Fremont Valley is to the north of Antelope Valley. The Antelope Valley Groundwater Basin underlies approximately 1.01 million acres and is comprised of two primary aquifers — the upper or principal aquifer and the lower or deep aquifer. The principal aquifer is unconfined and generally thickest in the southern portion of the valley. The deep aquifer is confined and thickest near the dry lakes in the northeastern portion of the valley (California Department of Water Resources 2003). The primary water-bearing materials consist of Pleistocene- to Holocene-age alluvial deposits, floodplain deposits, and lacustrine deposits that contain coarse gravels near the mountain fronts and become finer-grained toward the central portion of the valley. The principal aquifer is recharged by percolation of perennial streamflow into the alluvial fans at the base of the surrounding mountains. In addition to natural recharge, the principal aquifer is artificially recharged by injecting recycled water and water from the SWP into aquifer storage and recovery wells. Agricultural irrigation and infiltration of water from canals also replenish the aquifers (Antelope Valley Regional Water Management Plan 2007).

Fremont Valley Groundwater Basin

The Fremont Valley Groundwater Basin (6-46) underlies about 335,000 acres in the Fremont Valley, which is adjacent to the north of Antelope Valley. The basin is bounded by the Garlock fault zone and the Sierra Nevada and El Paso Mountains to the northwest, and the Summit Range, Red Mountain, Lava Mountains, Rand Mountains, Castle Butte, Bissel Hills, and the Rosamond Hills to the east. The primary groundwater-bearing deposits are unconsolidated Quaternary alluvial deposits which underlie most of the valley (California Department of Water Resources 1969). The Pleistocene-age coarse alluvial-fan deposits yield little water to wells.The Holocene alluvial deposits are typically above the water table, except in lower parts of the valley. In areas where the Holocene alluvial deposits are below the water table, the well yield is low (California Department of Water Resources 1969). The alluvium has a maximum thickness of 1,190 feet near the margins of the basin and gets thinner toward the center of the basin (California Department of Water Resources 2003). Recharge to the aquifer occurs by subsurface inflow from the Chaffee area and by runoff from the North Muroc area in Antelope Valley (California Department of Water Resources 1969).

Owens Valley Groundwater Basin

The Owens Valley Groundwater Basin (6-12) underlies about 661,000 acres in the Owens Valley and is bound by the Benton Range to the north, the Coso Range to the south, the Sierra Nevada to the west, and the White and Inyo mountains to the east. Numerous creeks drain into the Owens River, which flows southward toward the Owens Dry Lake. The primary water-bearing materials of the basin are sediments that fill the valley from the surrounding mountains. Volcanic deposits interbedded with the sediments also store groundwater. The water-bearing deposits reach a thickness of at least 1,200 feet and are separated into upper, middle, and lower members. The upper member consists of unconsolidated coarse alluvial-fan deposits and is generally unconfined throughout the aquifer. It is estimated to have a saturated thickness of approximately 100 feet (Danskin 1998). The middle member is generally a semi-confining layer that restricts vertical movement of groundwater. The middle member consists of fine-grained fluvial and lacustrine deposits and low-permeability volcanic materials. Generally, the thickness of the unit is 15 feet or less, but in some areas near the central portion of the basin, the unit is at least 80 feet thick (California Department of Water Resources 2003). The lower member contains several confined zones that generally extend across the length of the valley. The lower member consists of older alluvial-fan deposits, fluvial and lacustrine deposits, and the Bishop Tuff, where it is present. This member ranges in thickness from tens of feet along the margins of the valley to approximately 500 feet in the central portion of the basin. The aquifers are primarily recharged by streamflow percolation into the alluvial fans along the base of the surrounding mountains (Danskin 1998).

Indian Wells Valley Groundwater Basin

The Indian Wells Valley Groundwater Basin (6-54) underlies approximately 382,000 acres in Indian Wells Valley. The internally drained basin is located east of the southern Sierra Nevada and is bounded by the Coso Range to the north, Argus Range to the east, and El Paso Mountains to the south. The basin is filled with sediment eroded from the surrounding highlands to an average depth of 4,000 feet, although the sediment can be as thick as 7,000 feet in the western portion of the valley (Eastern Kern County Resource Conservation District 2003). The primary water-bearing deposits consist of Pleistocene to Holocene lacustrine, fluvial, and alluvial-fan deposits which form an upper and lower aquifer system. The upper aquifer ranges in thickness from 0 foot to 130 feet deep and underlies the areas west of and south of China Lake (California Department of Water Resources 2003). The upper aquifer is unconfined and is primarily composed of alluvium and fine-grained lacustrine deposits (Eastern Kern County Resource Conservation District 2003). The lower aquifer is primarily composed of alluvial-fan deposits with sand and gravel interbedded with lacustrine clay. In general, the groundwater in the lower aquifer is unconfined, except in the eastern portion of the valley. Depending on the presence and abundance of lacustrine clay, groundwater is unconfined, semi-confined, and confined within the lower aquifer. Most of the groundwater that is supplied to the nearby communities is pumped from the western and southwestern portions of the basin. The aquifers are primarily recharged by infiltration of surface runoff from the surrounding mountains and, to a lesser degree, artificial recharge through irrigation runoff and leakage from the Owens Valley aqueduct, municipal distribution lines, and wastewater treatment plants (Eastern Kern County Resource Conservation District 2003).

Mojave River Valley Groundwater Basins

The Upper, Middle, and Lower Mojave River Valley groundwater basins are adjacent groundwater basins drained by the Mojave River. Collectively, the three groundwater basins underlie approximately 910,000 acres and are bounded on the west by the Shadow Mountains, El Mirage Valley, and Harper Valley. The basins are bounded on the north by Harper Valley, Waterman and Calico mountains, and Coyote Lake Valley; on the east by the Cady Mountains and Pisgah fault; and on the south by Daggett Ridge, the Newberry, Rodman, and San Bernardino mountains. Numerous faults that affect groundwater flow have been identified in the vicinity of the groundwater basins. The prominent faults are the northwest-trending Helendale, Mount General, Lenwood, Camp Rock-Harper Lake, Calico-Newberry, and Pisgah faults (California Department of Water Resources 2003).

Groundwater conditions are generally unconfined in the Mojave River Valley groundwater basins (California Department of Water Resources 2003). The two primary water-bearing units consist of a regional alluvial-fan unit and an overlying floodplain unit. The regional fan unit is composed of Pliocene and Quaternary unconsolidated-to-partially-consolidated alluvial-fan deposits. This unit has a maximum thickness ranging from 1,000 feet in the Upper Mojave River Valley to 2,000 feet in the Middle and Lower Mojave River Valley basins, with an average thickness of approximately 300 feet in all basins (California Department of Water Resources 1967). The overlying floodplain unit is Pleistocene age and is the more productive water-bearing unit. The floodplain unit has an average thickness of 150 feet in the Upper Mojave River Valley basin and 200 feet in the Middle and Lower Mojave River Valley basins. The floodplain unit is generally deposited within 1 mile of the Mojave River and is composed of coarser material than the underlying regional alluvial-fan unit. The average specific yield of the floodplain unit ranges from 27 percent in the Upper Mojave River Valley Basin to 22 percent and 18 percent in the Middle and Lower Mojave River Valley basins, respectively (Lines 1996). The specific yield of the regional alluvial-fan unit averages approximately 10 percent in each of the three basins (California Department of Water Resources 1967). Approximately 80 percent of the recharge to the aquifers occurs by infiltration of water from the Mojave River (Mojave Water Agency 2004). The remaining recharge occurs by infiltration of storm runoff from the surrounding mountains and by artificial recharge resulting from irrigation, fish hatcheries, and the application of imported and treated wastewater (Mojave Water Agency 2004).

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. Generally, wells drawing from fractured-rock aquifers yield less than 10 gallons per minute (gpm). Although fractured-rock aquifers are less productive compared with the alluvial aquifers in the region, they are commonly the sole source of water and a critically important water supply for many communities. A detailed description of the fractured-rock aquifers in the South Lahontan region is beyond the scope of this analysis for *California Water Plan Update 2013*.

Well Infrastructure

A key aspect to understanding the region's groundwater supply and development is identifying the age, distribution, and type of wells that have been drilled in the region. A valuable source of well information is the well completion reports, or well logs, submitted by licensed well drillers to the landowner, the local county department of environmental health, and DWR. Among other things, well logs commonly identify well location, construction details, borehole geology data, installation date, 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 that construct, alter, abandon, or destroy a well to submit a well log to DWR within 60 days of the completed work. Well logs submitted to DWR for wells completed from 1977 through 2010 were used to evaluate the distribution and the uses of groundwater wells in the region. DWR does not have well logs for all the wells completed in the region. For some well logs, information regarding well location or use is inaccurate, incomplete, ambiguous, or missing. Consequently, some well logs could not be used in the evaluation. But for a regional scale evaluation of well installation 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 in Appendix A.

The number and distribution of wells in the South Lahontan region are grouped according to their location by county, and according to the six most common well-use types: domestic, irrigation, public supply, industrial, monitoring, and other. Public supply wells include all wells identified on the well completion report as municipal or public. 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).

The South Lahontan region includes all of Inyo County and portions of Kern, Los Angeles, Mono, and San Bernardino counties. Well-log data for counties that fall within multiple hydrologic regions were assigned to the hydrologic region containing a majority of alluvial groundwater basins within the region, or to the region with more groundwater production. Although portions of Kern County and Los Angeles County are within the South Lahontan region, these counties will be evaluated within the Tulare Lake Hydrologic Region and the South Coast Hydrologic Region chapters, respectively. By the same rule, well-log data for wells in Mono County and San Bernardino County that are outside of the South Lahontan region will be included in the South Lahontan Hydrologic Region analysis. Because of the boundary assumptions, the number and types of wells listed by county are not necessarily indicative of the number and types of wells within the hydrologic region.

Table 11-2 lists the number of well logs received by DWR for wells completed in the South Lahontan region from 1977 to 2010, which includes wells in Inyo, Mono, and San Bernardino counties. Figure 11-3 and Figure 11-4 provide illustrations of this data by county and for the region as a whole.

Table 11-2 Number of Well Logs, According to Well Use and by County, for the South Lahontan Hydrologic Region (1977-2010)

County	Total Number of Well Logs by Well Use						Total Well Records
	Domestic	Irrigation	Public Supply	Industrial	Monitoring	Other	
Mono	765	34	81	3	91	73	1,047
Inyo	603	55	76	32	170	195	1,131
San Bernardino	6,026	432	1,135	161	2,068	1,112	10,934
Total Well Records	**7,394**	**521**	**1,292**	**196**	**2,329**	**1,380**	**13,112**

Figure 11-3 Number of Well Logs by County and Use for the South Lahontan Hydrologic Region (1977-2010)

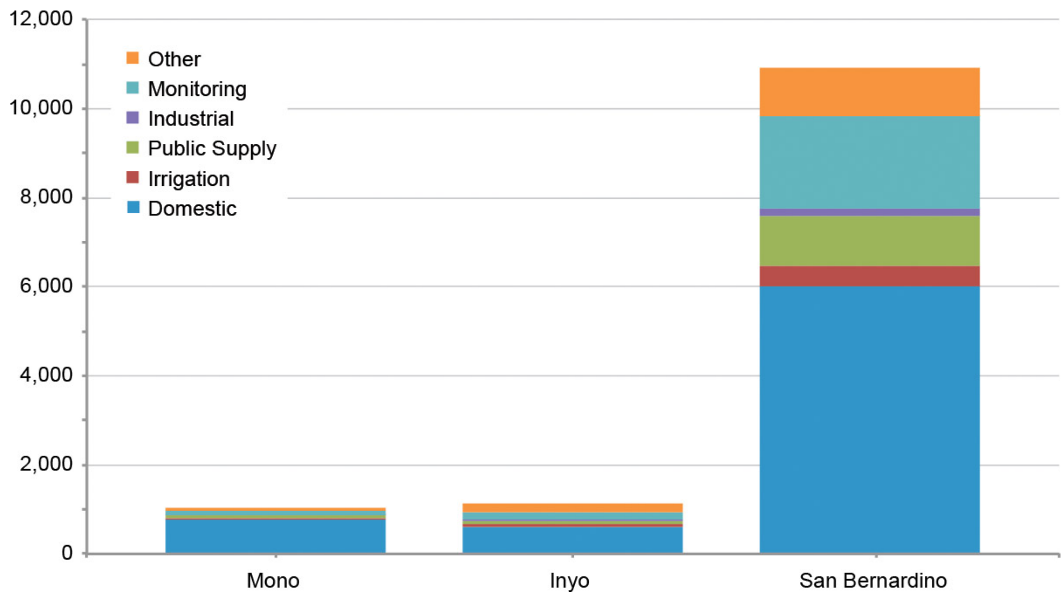
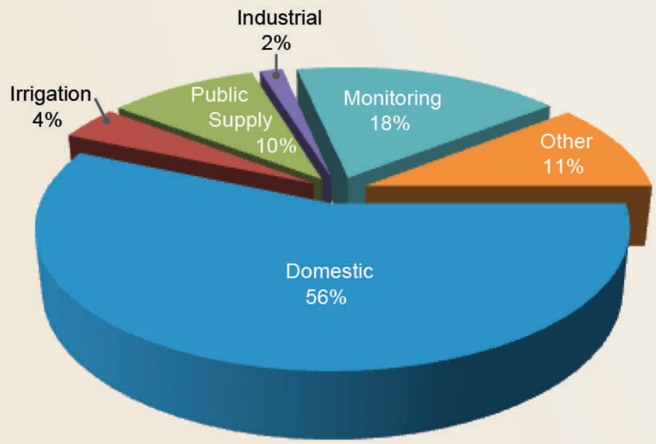


Table 11-2 and Figure 11-3 show that the distribution and number of wells vary widely by county and by use. The number of wells completed in the South Lahontan region between 1977 and 2010 is approximately 13,112, with more than 83 percent of those wells located in San Bernardino County. The small number of wells in Mono County and Inyo County reflects the sparse population in those areas.

Figure 11-4 displays the percentage of wells, by well use, for the South Lahontan region between 1977 and 2010. The figure shows that domestic and monitoring wells account for more than 74 percent of all wells installed in the region, with domestic wells comprising 56 percent and monitoring wells accounting for about 18 percent of well logs on file. Statewide, domestic and monitoring wells average about 54 and 24 percent, respectively, of the total number of wells. Although groundwater accounts for approximately 72 percent of the agricultural water supply for the South Lahontan region, irrigation wells comprise only about 4 percent of the wells in the region, which is lower than the statewide average of 10 percent. In general, irrigation wells pump groundwater at a much higher capacity than domestic wells.

Figure 11-4 Percentage of Well Logs by Type of Use for the South Lahontan Hydrologic Region (1977-2010)



South Lahontan Well Logs Summary by Well Type

Well Type	Number of Well Logs
Domestic	7,394
Irrigation	521
Public Supply	1,292
Industrial	196
Monitoring	2,329
Other	1,380
Total	**13,112**

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

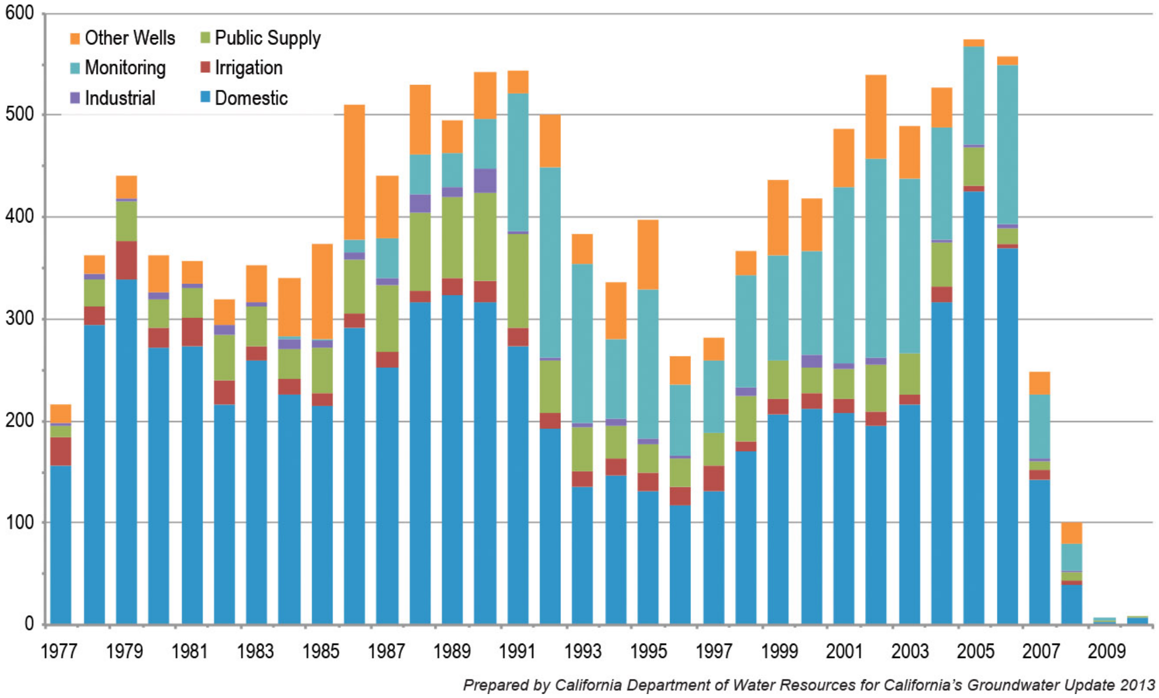
In addition to analyzing the number of wells by location and use, well logs were analyzed by well installation date (Figure 11-5). Evaluating the number and types of wells completed over time can help offer a perspective on the average age of the existing well infrastructure and the general pattern of wells installed during various hydrologic and economic cycles. Well-log records for the 2007-2010 period are not complete because of constraints associated with processing and incorporating the data at the time of the data analysis.

Figure 11-5 shows a cyclic pattern of well installation for the South Lahontan region, with new well construction ranging from about 216 to 575 wells per year. Multiple factors are known to affect the annual number and type of wells constructed. Some of these factors include the annual variations in climate, economy, agricultural cropping trends, and alternative water supply availability.

Large fluctuations in the number of domestic wells completed in a given year are likely associated with fluctuations in population growth and residential housing construction trends, primarily in San Bernardino County. An economic downturn in the early 1990s resulted in a decline in the population growth and the completion of new domestic wells. Beginning in the late 1990s, the rise in the number of domestic wells completed is likely attributed to the resurgence in residential housing construction. The 2007-2010 decline in domestic well completion was likely caused by declining economic conditions and a drop in new home construction. The apparent decline in well completions during that time was also largely caused by DWR's backlog in processing the well logs received.

Irrigation well completions are more closely related to weather conditions, cropping trends, and availability of surface-water supply. Figure 11-5 shows a steady rate of irrigation well completions, with a slight increase following dry year conditions. On average, less than 40 irrigation wells per year are completed in the region. Most are installed in San Bernardino County.

Figure 11-5 Number of Well Logs per Year, According to Well Use, for the South Lahontan Hydrologic Region (1977-2010)



The onset of monitoring-well installation in the mid- to late-1980s is likely associated with federal underground storage tank programs signed into law in the mid-1980s. Before 1987, the number of monitoring wells completed in the South Lahontan region was less than 13 wells per year. The number of monitoring wells drilled increased from 39 wells in 1987, to a high of 195 wells in 2002.

In 1984, the State of California Underground Storage Tank program took effect. The program provided partial reimbursement of expenses associated with the cleanup of leaking underground storage tanks. It quickly resulted in an increase in the installation of groundwater quality monitoring wells. Beginning in 1987, changes in California Water Code Section13751 required well drillers to submit well logs for monitoring well completions. Well logs typically do not distinguish between monitoring wells installed as part of a groundwater cleanup project and those installed primarily to collect changes in groundwater levels. But information on the well logs supports a conclusion that the majority of the monitoring wells were completed for use in environmental assessments related to leaking underground storage tanks, waste disposal sites, or hazardous chemical spills.

CASGEM Basin Prioritization

As part of the California's 2009 Comprehensive Water Package legislation (SB X7-6), DWR implemented the 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 requires DWR to identify the current extent of groundwater elevation monitoring within each of the alluvial groundwater basins defined under Bulletin 118-2003 and to prioritize those basins, so as to help identify, evaluate, and determine the need for additional groundwater-level monitoring. The basin prioritization process (California Water Code Section 10933[b]) directs DWR to consider, to the extent data are available, the following eight components:

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 and categorized them into four prioritization groups: high, medium, low, and very low.

Table 11-3 lists the priority categories of the CASGEM groundwater basins for the South Lahontan region. Figure 11-6 identifies these basins on a map. The full listing of the CASGEM groundwater basin prioritization is provided in Appendix B. Of the 77 basins within the South Lahontan region, two basins were identified as high priority (Upper Mojave River Valley Groundwater Basin and Antelope Valley Groundwater Basin), three basins were identified as medium priority, seven were listed as low priority, and the other 65 basins are listed as very low priority.

Although the primary intent of basin prioritization is to assist DWR in implementing the CASGEM Program, which is based on the comprehensive set of data included in the analysis, basin prioritization is also a valuable statewide tool to help evaluate, focus, and align limited resources. Basin prioritization is also an important tool to implement effective groundwater management practices by improving the statewide reliability and sustainability of groundwater resources.

In the South Lahontan region, implementation of sustainable groundwater resource management should initially be focused on the five basins listed in Table 11-3 as having a medium or high priority. The five basins designated as high or medium priority include 55 percent of the average annual groundwater use in the region and 94 percent of the 2010 population that overlies these groundwater basins.

Figure 11-6 CASGEM Groundwater Basin Prioritization for the South Lahontan Hydrologic Region

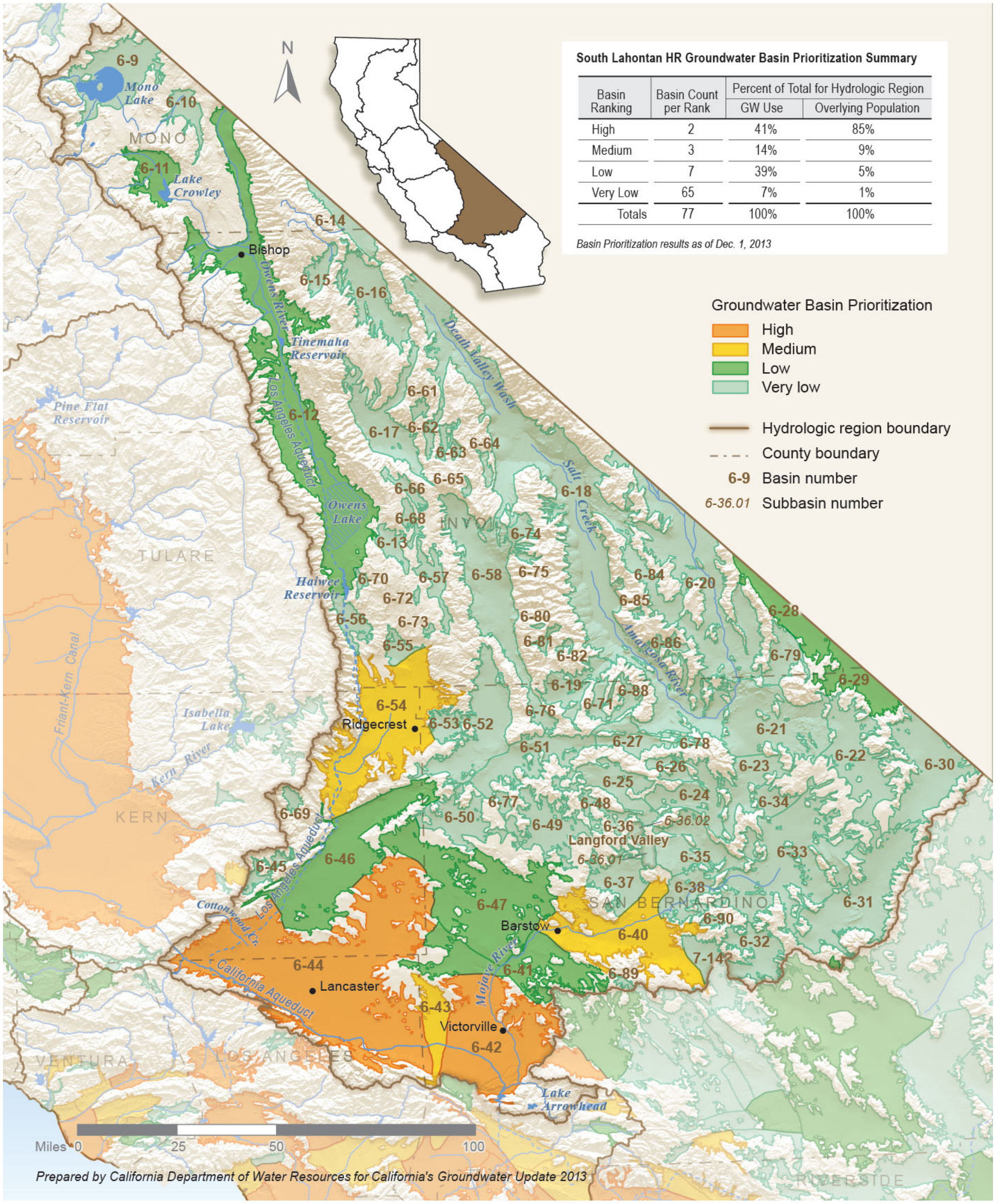


Table 11-3 CASGEM Prioritization for Groundwater Basins in the South Lahontan Hydrologic Region

Basin Priority	Count	Basin/Subbasin Number	Basin Name	Subbasin Name	2010 Census Population
High	1	6-42	Upper Mojave River Valley		355,338
High	2	6-44	Antelope Valley		398,864
Medium	1	6-43	El Mirage Valley		10,933
Medium	2	6-54	Indian Wells Valley		34,837
Medium	3	6-40	Lower Mojave River Valley		32,938
Low	7	See Appendix B			
Very Low	65	See Appendix B			
Total	**77**	**Population of South Lahontan Groundwater Basin Area:**			**889,749**[a]

Notes:
[a]Population of groundwater basin area includes the population of all basins within South Lahontan Hydrologic Region.
Ranking as of December 2013.
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 California Statewide Groundwater Elevation Monitoring Program, the California Department of Water Resources 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 California Department of Water Resources.
Using groundwater reliance as the leading indicator of basin priority, the California Department of Water Resources evaluated California's 515 alluvial groundwater basins and categorized them into four groups — high, medium, low, and very low.

Groundwater Use

The amount and timing of groundwater extraction, along with the location and type of groundwater use, are fundamental components for building 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 publically record their annual groundwater extraction amount. 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 the first to be used 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 employing conjunctive management practices, which may involve frequent exchanges between surface water and groundwater supplies, making accurate estimates of annual groundwater extraction by using the land and water-use method can be challenging.

DWR water supply and balance data are collected and analyzed by hydrologic regions, which largely correspond to watershed boundaries. The land and water-use data are first compiled and analyzed by detailed analysis units (DAUs). Water supply and balance data for DAUs are then compiled into larger planning areas, 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 local groundwater basins, DWR does not currently generate groundwater-use 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 wetland uses. Reference to total water supply for a region represents the sum of surface-water supplies, groundwater supplies, and reused/recycled water supplies. Reused/recycled water supplies include desalinated water supplies. Groundwater-use information is presented according to planning area, county, and type of use. Additional information regarding water-use analysis is provided in Appendix A and Appendix C.

2005-2010 Average Annual Groundwater Supply

Water demands in the South Lahontan region are met through a combination of supplies from the SWP, imported surface water, local groundwater, and recycled water supplies. The 2005-2010 average annual total water supply for the region is estimated at 668 taf, which includes approximately 79 taf of reuse water. Groundwater contributes approximately 441 taf (66 percent) toward the total water supply, with the remaining supply met by the SWP, local supplies, and recycled water. Groundwater extraction in the South Lahontan region accounts for about 3 percent of California's 2005-2010 average annual groundwater use; nonetheless, groundwater provides 100 percent of the water supply for some communities in the region and is an important resource to help facilitate conjunctive management in the region.

Groundwater Use by Planning Area Boundaries

The South Lahontan region includes five planning areas, Mono-Owens Planning Area (PA), Indian Wells PA, Death Valley PA, Antelope Valley PA, and Mojave River PA. Table 11-4 lists the 2005-2010 average annual total water supply met by groundwater, according to planning area, and by type of use. It shows the quantity and percentage of groundwater contributing to the total water supply, according to planning area and type of use for the region. Table 11-5 identifies the percentage of groundwater used to meet the South Lahontan region's annual supply according to planning area and type of use. Figure 11-7 shows the planning area locations for the region and illustrates the groundwater-use information presented in Table 11-4 and Table 11-5.

As shown in Figure 11-7, the 2005-2010 average annual total water supply for the South Lahontan region is 668 taf, with groundwater contributing 441 taf toward the region's total supply. Groundwater supplies meet about 58 percent (170 taf) of the region's urban water use and 72 percent (271 taf) of the region's agricultural needs.

Table 11-4 Average Annual Groundwater Supply and Percentage of Total Water Supply, According to Planning Area and Type of Use, for the South Lahontan Hydrologic Region (2005-2010)

South Lahontan Hydrologic Region		Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use[a] Met by Groundwater	
PA Number	PA Name	taf	%[b]	taf	%[b]	taf	%[b]	taf	%[b]
901	Mono-Owens	137.4	76%	10.5	90%	0	0%	147.9	77%
902	Indian Wells	10.3	100%	19.4	98%	0	0%	29.7	99%
903	Death Valley	10.6	100%	4.0	100%	0	0%	14.7	100%
904	Antelope Valley	57.6	73%	40.7	32%	0	0%	98.3	48%
905	Mojave River	54.7	57%	95.7	73%	0	0%	150.4	66%
2005-2010 Annual Average HR Total		**270.6**	**72%**	**170.3**	**58%**	**0**	**0%**	**440.9**	**66%**

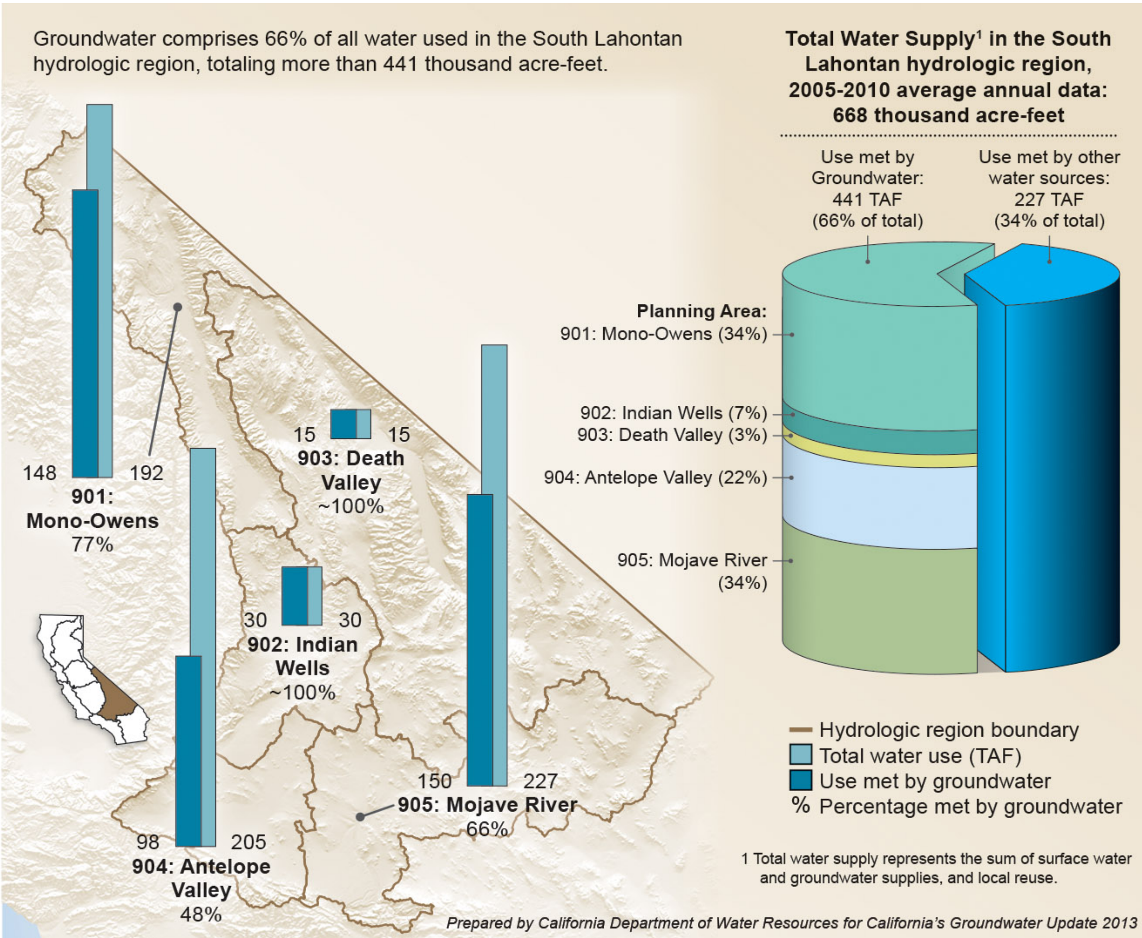
Notes:
HR = hydrologic region, PA = planning area, taf = thousand acre-feet
[a]Total water use = groundwater + surface water + reuse
[b]Percent use is the percent of the total water supply that is met by groundwater, by type of use.
2005-2010 precipitation equals 92 percent of the 30-year average for the South Lahontan Hydrologic Region.

Table 11-5 Percentage of Average Annual Groundwater Supply, According to Planning Area and Type of Use for the South Lahontan Hydrologic Region (2005-2010)

South Lahontan Hydrologic Region		Agriculture Use of Groundwater	Urban Use of Groundwater	Managed Wetlands Use of Groundwater	Groundwater Use by PA
PA Number	PA Name	%[a]	%[a]	%[a]	%[b]
901	Mono-Owens	93%	7%	0%	34%
902	Indian Wells	35%	65%	0%	7%
903	Death Valley	73%	28%	0%	3%
904	Antelope Valley	59%	41%	0%	22%
905	Mojave River	36%	64%	0%	34%
2005-2010 Annual Average HR Total		**61%**	**39%**	**0%**	**100%**

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

Figure 11-7 Groundwater Use and Total Water Supply Met by Groundwater, According to Planning Area, in the South Lahontan Hydrologic Region (2005-2010)



Groundwater resources for the Indian Wells PA and Death Valley PA account for 10 percent (44 taf) of the 2005-2010 average annual groundwater use for the region. To meet the agricultural and urban water demands of those areas, the Indian Wells PA is 98 percent reliant on groundwater and the Death Valley PA is 100 percent reliant on groundwater.

The Mojave River PA and the Mono-Owens PA are also heavily reliant on groundwater. Based on 2005-2010 averages, they collectively use about 68 percent of the groundwater extracted in the South Lahontan region. In the Mojave River PA, 66 percent of the urban and agricultural water demands are met by groundwater. The Mono-Owens PA relies on groundwater to meet 77 percent of its total water needs. The Antelope Valley PA uses the most surface water in the region, with groundwater meeting 48 percent of the planning area's 205 taf annual water demand (Table 11-4).

Groundwater Use by County Boundaries

Groundwater supply and use was also calculated by county for the South Lahontan region. Inyo County is fully within the South Lahontan region, while Kern, Los Angeles, Mono, and San Bernardino counties are partially within the South Lahontan region. For the South Lahontan region, groundwater use by county is only reported for Inyo, Mono, and San Bernardino counties. Groundwater use for Los Angeles County is discussed in the South Coast Hydrologic Region chapter, and groundwater use for Kern County is discussed in the Tulare Lake Hydrologic Region chapter. Tables showing groundwater use for all 58 California counties are provided in Appendix C.

County boundaries do not align with planning area or hydrologic region boundaries, so regional totals for groundwater based on county boundaries will vary from the planning area estimates shown in Table 11-4. The 2005-2010 average annual total water supply for the region, based on county boundaries, is estimated at 1,122 taf, with groundwater contributing 697 taf toward that supply. Of the groundwater used in the South Lahontan region, approximately 77 percent is extracted from San Bernardino County to meet 68 percent of its water needs. Table 11-6 shows that groundwater meets between 37 percent and 70 percent of the total water supply for the three counties, with Inyo County being the most reliant on groundwater supplies. Groundwater provides 100 percent of Inyo County’s urban water needs.

Table 11-6 Groundwater Use and Percentage of Total Water Supply Met by Groundwater, According to County and Type of Use, for the South Lahontan Hydrologic Region (2005-2010)

South Lahontan Hydrologic Region	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groundwater	
County	**taf**	**%[a]**	**taf**	**%[a]**	**taf**	**%[a]**	**taf**	**%**
Inyo	59.4	67%	11.1	100%	0.0	0%	70.5	70%
Mono	82.9	36%	3.4	69%	0.0	0%	86.3	37%
San Bernardino	116.9	65%	423.2	69%	0.0	0%	540.1	68%
2005-2010 Annual Average Total	**259.2**	**52%**	**437.7**	**70%**	**0.0**	**0%**	**696.9**	**62%**

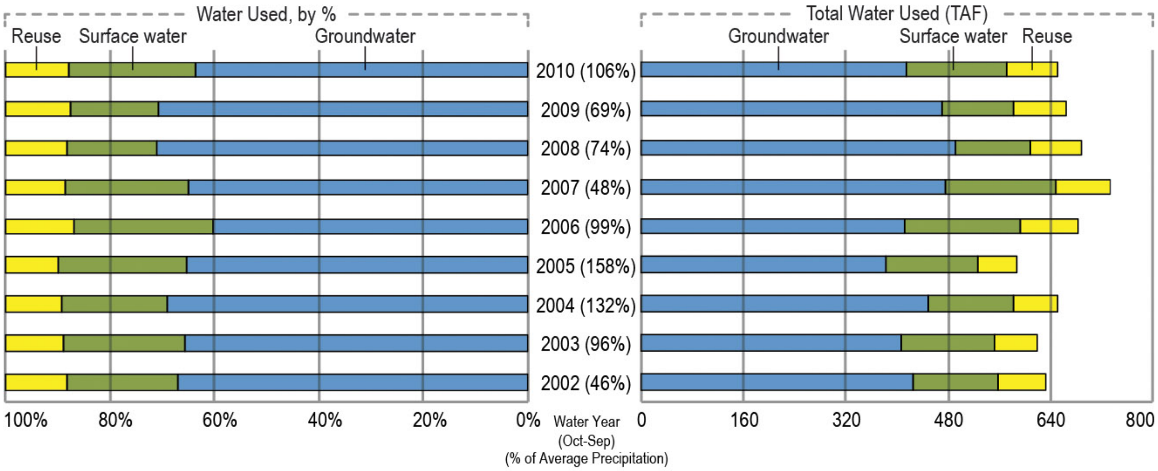
Notes:
taf = thousand acre-feet
[a]Percent use is the percentage of the total water supply that is met by groundwater, by type of use.
2005-2010 precipitation equals 92 percent of the 30-year average for the South Lahontan Hydrologic Region.

Change in Annual Groundwater Use

Changes in annual amount and type of groundwater use may be related to a number of factors, such as changes in surface-water availability, urban and agricultural growth, economic fluctuations, and water use efficiency practices.

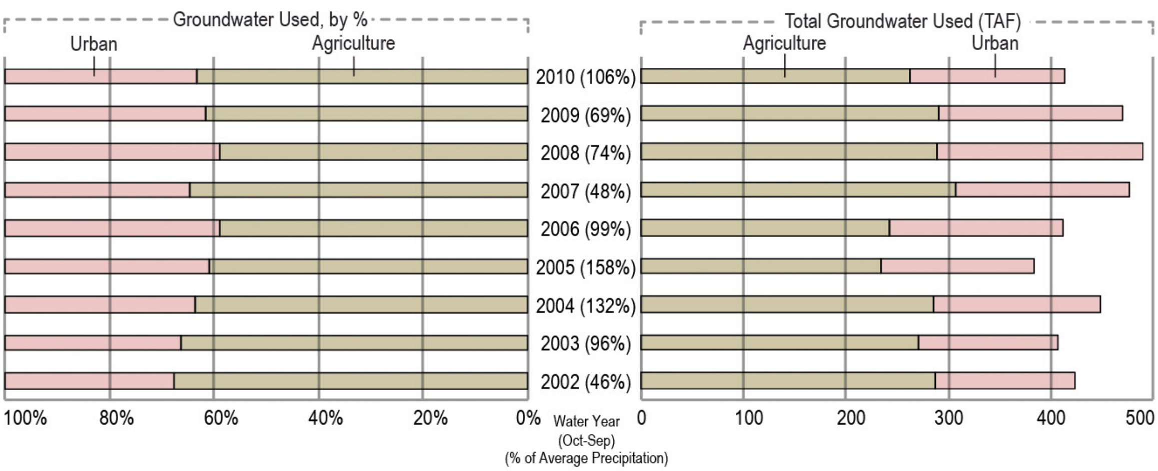
Figure 11-8 illustrates the 2002-2010 total water supply trend for the South Lahontan region, while Figure 11-9 shows the annual amount and percentage of groundwater supply used to meet urban and agricultural demand during the same period. The right side of Figure 11-8 illustrates the total water supply volume by supply type (groundwater, surface water, and reused/recycled water), while the left side shows the percentage of the overall water supply met by those sources of water. The center column in both figures identifies the water year, along with the

Figure 11-8 Annual Surface Water and Groundwater Supply Trend for the South Lahontan Hydrologic Region (2002-2010)



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

Figure 11-9 Annual Groundwater Supply Trend by Type of Use for the South Lahontan Hydrologic Region (2002-2010)



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corresponding amount of precipitation, as a percentage of the previous 30-year average, for the hydrologic region. There are no managed wetlands identified in the region.

As shown in Figure 11-8, the annual water supply for the South Lahontan region ranged between 586 taf (2005) and 733 taf (2007). During each of the water years shown, groundwater use ranged between 384 taf and 491 taf, and met 60 percent to 71 percent of the annual total water supply for the region. Between 2002 and 2010, surface water contributed 17 percent to 27 percent of the total water supply for the South Lahontan region, and ranged between 112 taf (2009) and 182 taf (2006). During the drought years of 2007 to 2009, when precipitation ranged between 48 percent and 74 percent of the 30-year average for the region, the annual total water supply, as well as the amount that groundwater contributed to those water needs, were among the highest.

Figure 11-9 shows the 2002-2010 groundwater supply trend by urban, agricultural, and managed wetland uses in the South Lahontan region. The right side of Figure 11-9 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.

During this period, the annual groundwater use for agricultural needs exceeded urban demand in each of those years. The groundwater used to meet agricultural demand ranged from 59 percent to 68 percent of the annual groundwater extraction for the region, with the remaining groundwater extraction being used to meet urban demand. In general, despite the water year or the total amount of annual groundwater extracted in the South Lahontan region, the percentage of groundwater distribution to meet agricultural needs versus urban needs was fairly stable.

Groundwater Monitoring Efforts

Groundwater resource monitoring and evaluation is a key aspect 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 the 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 groundwater level, groundwater quality, and land subsidence monitoring activities in the South Lahontan region. The summary includes publically available groundwater data compiled by DWR, State Water Resources Control Board (SWRCB), California Department of Public Health (CDPH), 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 the region include DWR and USGS. 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 represents data that is publically available through DWR or USGS online information systems. Privately collected and locally maintain groundwater-level information is not discussed in this section. The groundwater-level information in this section only includes 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, groundwater-level information presented for the South Lahontan region may not represent the most current information available. Updated groundwater-level information may be obtained online from the DWR CASGEM Program Web site (http://www.water.ca.gov/groundwater/casgem/), and through the USGS National Water Information System (http://waterdata.usgs.gov/nwis).

A list of the number of monitoring wells in the South Lahontan region, by monitoring agencies, cooperators, and CASGEM-designated monitoring entities, is provided in Table 11-7. The locations of these monitoring wells, by monitoring entity and monitoring well type, are shown in Figure 11-10.

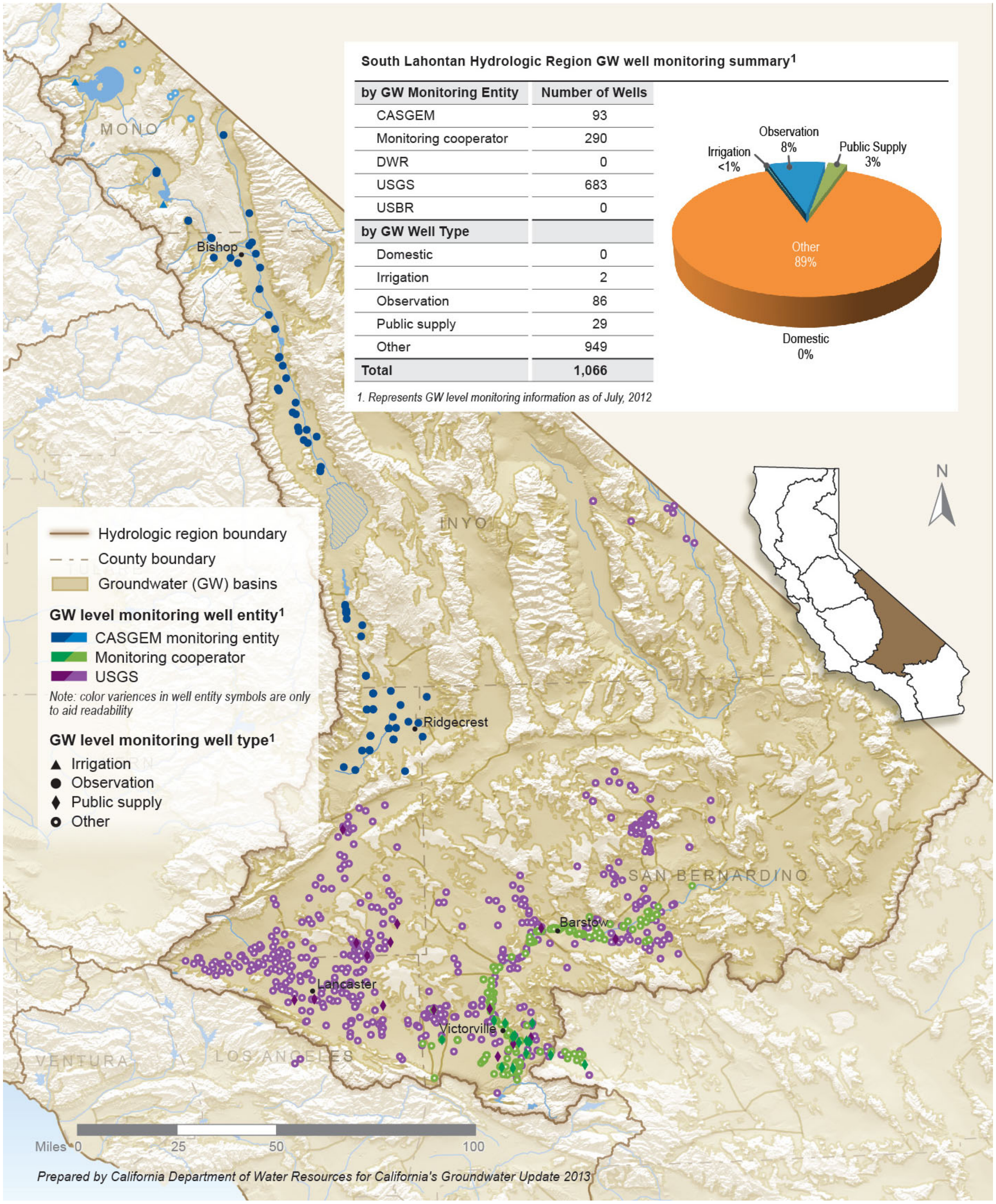
Table 11-7 shows that 1,066 wells in the South Lahontan region are actively monitored for groundwater-level information. The USGS monitoring network consists of 683 wells in 17 basins and subbasins and includes wells outside of Bulletin 118-2003 groundwater basins. Five cooperators and five CASGEM monitoring entities monitor a combined 383 wells in 12 basins and areas outside of Bulletin 118-2003 groundwater basins. Many of the groundwater-level monitoring wells are located in basins identified as having a high to medium priority under the CASGEM groundwater basin prioritization.

Most of the groundwater-level monitoring networks include a variety of well use types. The groundwater-level monitoring wells are categorized by the type of well use and include irrigation, domestic, observation, public supply, and other. 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 irrigations wells used for groundwater-level monitoring include actively operated wells and some consist of older, inactive, or unused wells.

Domestic wells are typically relatively shallow and screened in the upper portion of the aquifer system, while irrigation wells tend to be constructed deeper within the aquifer system. Consequently, groundwater-level data collected from domestic wells typically represent shallow aquifer conditions, while groundwater-level data from irrigation wells represent middle-to-deep aquifer conditions. Some observation wells are constructed as a nested or clustered set of dedicated monitoring wells, designed to characterize groundwater conditions at very specific and discrete production intervals throughout the aquifer system.

Figure 11-10 indicates agencies that collect the groundwater elevation data, and it displays groundwater-level monitoring wells by use. A percentage breakdown of the groundwater-level monitoring wells by use, illustrated by the pie chart, indicates that wells identified for irrigation and "other" account for 89 percent of the groundwater-level monitoring wells in the region. Most of these wells are located in the Owens Valley, Antelope Valley, El Mirage Valley, and the Upper, Middle, and Lower Mojave River Valley groundwater basins. Observation wells and public supply wells comprise 8 percent and 3 percent, respectively, of the wells identified as monitoring wells. No domestic wells and only two irrigation wells are part of the groundwater-level monitoring grid for the region.

Figure 11-10 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity for the South Lahontan Hydrologic Region



South Lahontan Hydrologic Region GW well monitoring summary[1]

by GW Monitoring Entity	Number of Wells
CASGEM	93
Monitoring cooperator	290
DWR	0
USGS	683
USBR	0
by GW Well Type	
Domestic	0
Irrigation	2
Observation	86
Public supply	29
Other	949
Total	**1,066**

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

Table 11-7 Groundwater-Level Monitoring Wells, by Monitoring Entity, for the South Lahontan Hydrologic Region

State and Federal Agencies	Number of Wells
California Department of Water Resources	0
U.S. Geological Survey	683
U.S. Bureau of Reclamation	0
Total State and Federal Wells	**683**
Monitoring Cooperators	**Number of Wells**
Apple Valley Ranchos Water Company	11
Hesperia County Water District	14
Mojave Water Agency	250
Sheep Creek Mutual Water Company	1
Southern California Water Company	14
Total Cooperator Wells	**290**
CASGEM Monitoring Entities	**Number of Wells**
Indian Wells Valley Cooperative Groundwater Management Group	39
Inyo County	11
Los Angeles Department of Water and Power	27
Mono County	14
Tri-Valley Groundwater Management District	2
Total CASGEM Entity Wells	**93**
Total Hydrologic Region Monitoring Wells	**1,066**

Notes:
CASGEM = California Statewide Groundwater Elevation Monitoring Program
Table represents monitoring information as of July 2012.
Table includes groundwater level monitoring wells having publically available online data.

Groundwater-Quality Monitoring

Groundwater-quality monitoring is an important aspect to 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. But monitoring is inconsistent throughout the state, with significant regional variation in parameters monitored, monitoring frequency, and data availability. Despite these inconsistencies, there are excellent examples of groundwater monitoring programs being implemented at the local, regional, and State levels.

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 GAMA Web site (http://www.waterboards.ca.gov/gama/geotracker_gama.shtml), and the

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 more than 200,000 wells. It contains more than 125 million data records. These data records were obtained from different sources such as the SWRCB, regional water quality control boards (RWQCBs), CDPH, California Department of Pesticide Regulation, USGS, and Lawrence Livermore National Laboratory (LLNL). 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 11-8 provides agency-specific groundwater quality information. Additional information regarding assessment and reporting of groundwater quality information is listed under the "Aquifer Conditions" section of this chapter.

Table 11-8 Sources of Groundwater Quality Information for the South Lahontan Hydrologic Region

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 • 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 **Groundwater Ambient Monitoring and Assessment (GAMA) Program** 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

Agency	Links to Information
	• 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 VI 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
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/	U.S. Environmental Protection Agency STORET Environmental Data System http://www.epa.gov/storet/
U.S. Geological Survey http://ca.water.usgs.gov/	U.S. Geological Survey Water Data for the Nation http://waterdata.usgs.gov/nwis

Land Subsidence Monitoring

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

USGS and MWA cooperatively monitored and investigated the occurrence of land subsidence in the Mojave Desert within the South Lahontan region. USGS has conducted land subsidence monitoring and reporting using a global positioning system (GPS) monitoring network in the Lancaster area within Antelope Valley (Phillips et al. 2003). Another investigation by USGS used extensometer data to study the land subsidence at Edwards Air Force Base in Antelope Valley (Sneed and Galloway 2000). Results associated with these monitoring activities are provided under the "Aquifer Conditions" section of this chapter. Additional information regarding land subsidence in California is provided in Appendix F.

Aquifer Conditions

Aquifer conditions and groundwater levels change in response to varying supply, demand, and weather 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. As a result, if groundwater levels rise sufficiently, water table aquifers can reconnect to surface-water systems, contributing to the overall base flow or directly discharging onto the ground surface via wetlands, seeps, and springs.

During dry years or periods of increased groundwater use, seasonal groundwater levels tend to fluctuate more widely and, depending on annual recharge conditions, may respond with a long-term decline in groundwater levels, both locally and regionally. Depending on the amount, timing, and duration of groundwater-level decline, affected well owners may need to deepen wells or lower pumps to regain access to groundwater.

Lowering of groundwater levels can also affect the surface-water–groundwater interaction by inducing additional infiltration and recharge from nearby surface-water systems, by reducing the groundwater contribution to the water base flow of surface-water systems, and by reducing groundwater discharge to wetlands areas. Extensive lowering of groundwater levels can also result in land subsidence caused by the dewatering, compaction, and loss of storage within finer-grained aquifer systems.

Groundwater Occurrence and Movement

Groundwater comes from infiltration of precipitation and of water from streams, canals and other surface-water systems, and moves from higher to lower elevation. Under predevelopment conditions, the occurrence and movement of groundwater was largely controlled by the surface and the subsurface geology, the size and distribution of the natural surface-water systems, the average annual hydrology, and the regional topography. But, many decades of high-volume groundwater extraction can considerably affect 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. High-capacity wells screened over multiple aquifer zones also lend themselves to vertical aquifer mixing, which can additionally alter natural groundwater flow conditions. Moreover, infiltration along unlined water conveyance canals, percolation of applied irrigation water, and direct recharge programs create significant groundwater recharge areas where none previously existed.

Depth to Groundwater

Understanding the local depth to groundwater provides a better awareness of the potential interaction between groundwater and surface-water systems, the relationship between land use and groundwater levels, the potential for land subsidence, groundwater contributions to the local ecosystems, and the costs associated with well installation and groundwater extraction. Under predevelopment aquifer conditions, changes in 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 depth to water and ground surface elevation will eventually start to break down and show significant variability. This can even occur in areas where there is little change in ground surface elevation.

Depth-to-groundwater data for some of the groundwater basins in the South Lahontan region are available online via DWR's Water Data Library, DWR's CASGEM Program (http://www.water.ca.gov/groundwater/casgem/), and the USGS National Water Information System (http://waterdata.usgs.gov/nwis/gw).

The Mojave Water Agency 2004 Regional Water Management Plan and USGS reports (2011 and 2007) contain depth-to-groundwater data for basins in the South Lahontan region within the MWA boundary. The Antelope Valley IRWM Plan contains depth-to-water data for portions of its planning area (Antelope Valley Integrated Regional Water Management Plan 2007). The Inyo-Mono IRWM Plan should be consulted for groundwater information specific to those counties.

No detailed depth-to-groundwater information was generated for the South Lahontan region as part of *California Water Plan Update 2013*.

Groundwater Elevations

Depth-to-groundwater measurements can be converted to groundwater elevations if the elevation of the ground surface is known. Groundwater elevation contours provide a good regional estimate of the occurrence and movement of groundwater. Similar to topographic contours, the pattern and spacing of groundwater elevation contours can be used to help estimate the direction of groundwater movement and the gradient, or rate, of groundwater flow. Groundwater elevation contours were not developed for the South Lahontan region as part of *California Water Plan Update 2013*.

Much of the land in the South Lahontan region is designated as public lands, including national forests, national parks, State parks, and military bases. As such, the population density is low in most of the region. The hydrogeology is not well understood in many of the basins because of the lack of development and infrastructure in the region. Some local agencies, independently or cooperatively, monitor groundwater elevations and produce groundwater elevation maps. Some references and links to local agencies that independently or cooperatively monitor the groundwater levels in the basins and develop groundwater elevation maps are provided in the previous section.

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 a time. Because the highly variable nature of the aquifer systems within each groundwater basin, and because of the variable nature of annual groundwater extraction, recharge, and surrounding land use practices, the hydrographs selected for discussion do not attempt to illustrate or depict average aquifer conditions over a broader region. Rather, the hydrographs were selected to help tell a story of how the local aquifer systems respond to changing groundwater extractions and implementation of resource management practices.

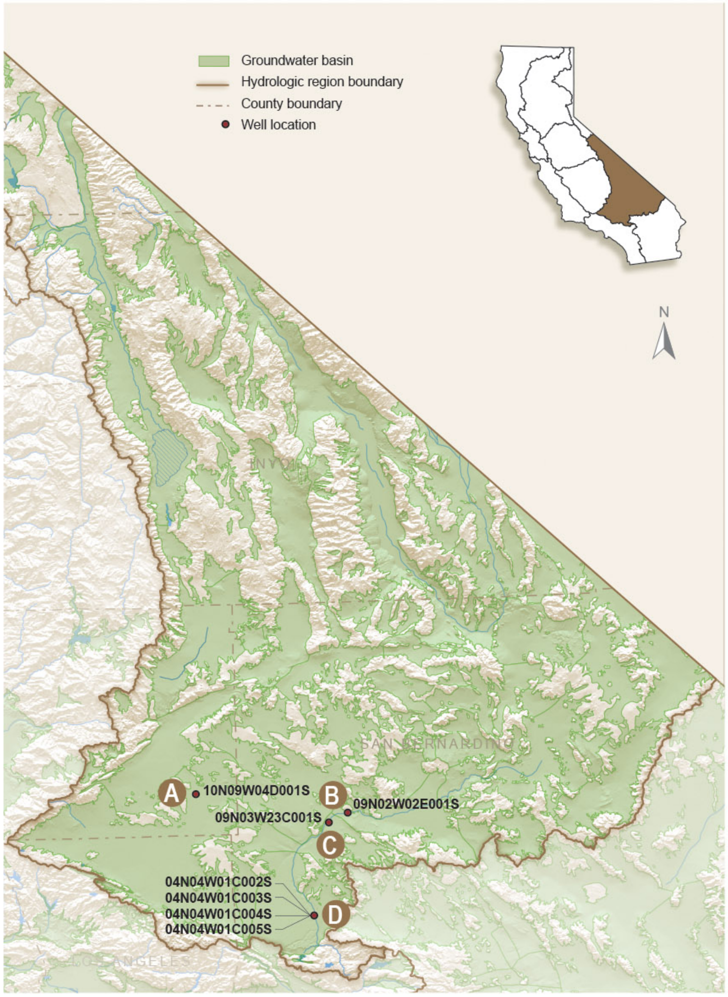
The hydrographs are identified according to the State Well Number (SWN) system. The SWN identifies a well by its location using the U.S. Public Lands Survey System of township, range, and section. More information on the SWN system is provided in DWR's *water facts* No. 7 information brochure (http://www.water.ca.gov/pubs/conservation/waterfacts/numbering_water_wells_in_california__water_facts_7_/water_facts_7.pdf).

Figure 11-11 shows hydrograph examples for four selected groundwater-elevation monitoring wells in the South Lahontan region and provides a brief explanation of the hydrograph story. More detailed information about the hydrograph can be found in the following paragraphs.

The Mojave River is the largest drainage system in the Mojave Desert. The Mojave River is an ephemeral river that is primarily fed by precipitation and snowmelt from the San Bernardino Mountains. The Mojave River overlies the Upper, Middle, and Lower Mojave River Valley groundwater basins and flows northeasterly to its terminus at Soda Lake. The hydrographs shown in Figure 11-11 display groundwater levels measured in wells which pump water from the Mojave River Flood Plain Aquifer located adjacent to the Mojave River. Although well completion details are lacking, the shallow groundwater levels in each well are assumed to represent unconfined groundwater conditions.

Figure 11-11 Groundwater Hydrographs for the South Lahontan Hydrologic Region, Page 1

Regional locator map

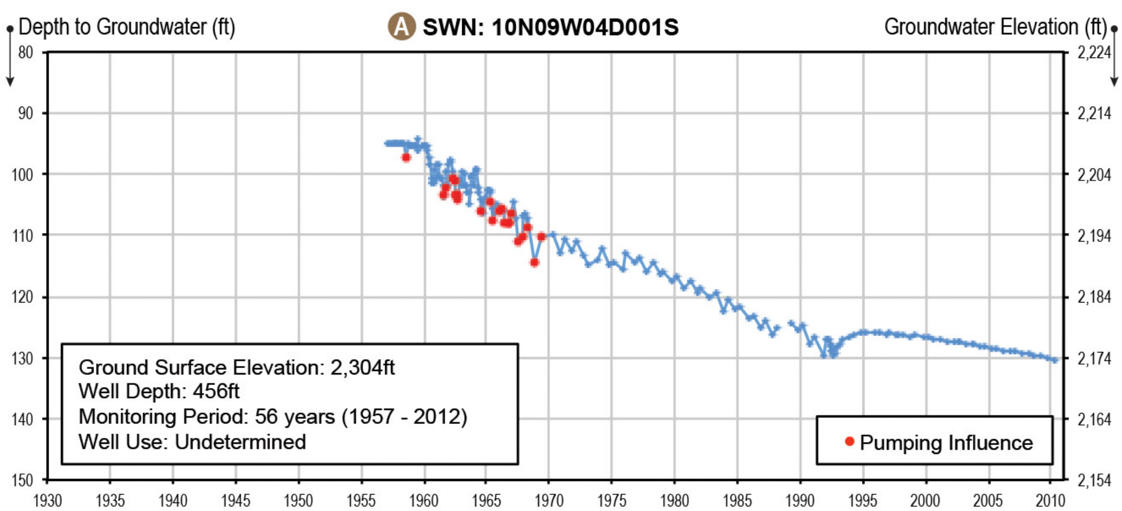


Aquifer response to changing demand and management practices

Hydrographs were selected to help tell a story of how local aquifer systems respond to changing groundwater demand and resource management practices. Additional detail is provided within the main text of the report.

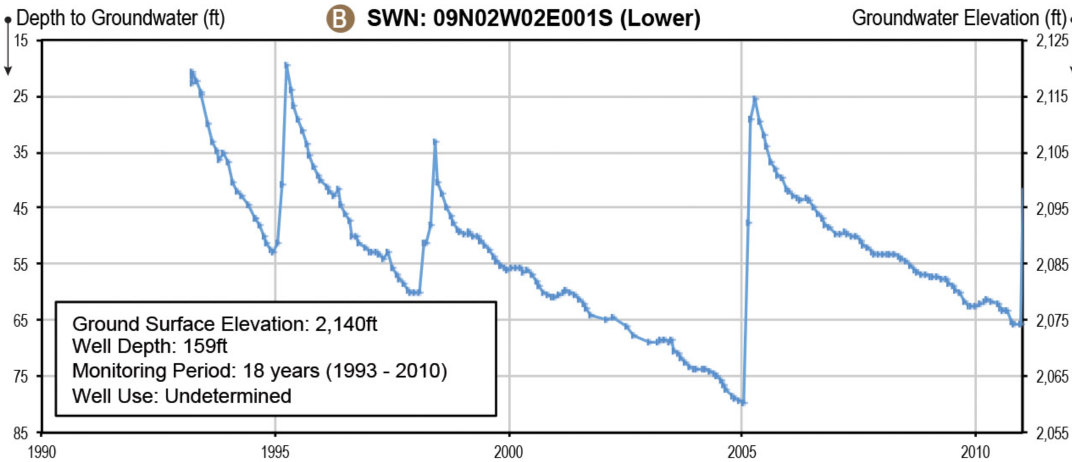
A Hydrograph 10N09W04D001S: illustrates the stabilization of declining groundwater levels through increased pumping costs and introduction of SWP water in 1970s. The rapid urban growth of 1980s, however, offset the recovery and resumed the downward trend in the groundwater levels.

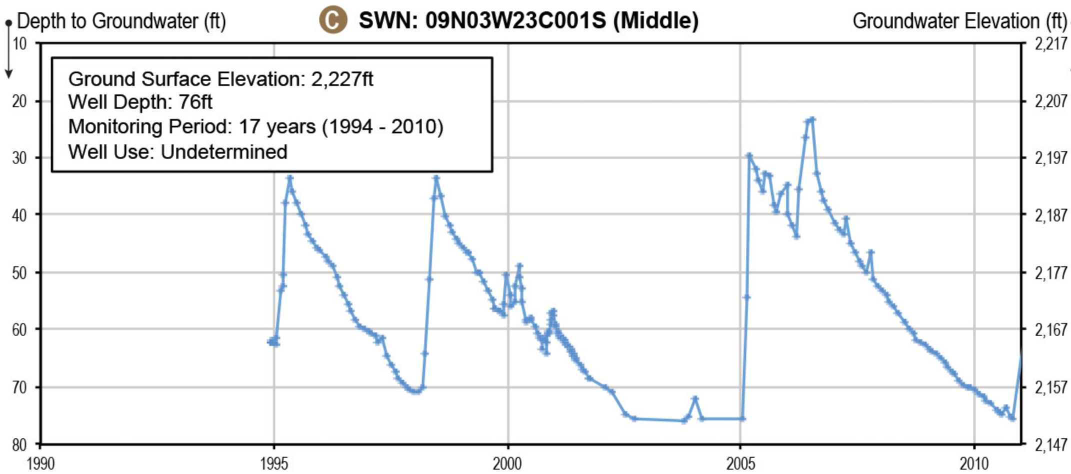
B C D Hydrograph 09N02W02E001S, 09N03W23C001S, and 04N04W01C002S-5S: highlights the inter-connected aquifer response to the precipitation conditions in the Lower, Middle and Upper Mojave River Valley Groundwater Basins, respectively. The aquifers underlying the three basins consist of very porous sediments which allow rapid water infiltration resulting in rapid increase in groundwater elevations during periods of heavy precipitation. The delayed recharge response in Middle and Lower Mojave River Groundwater Basins is most likely due the fact that the Mojave River is an ephemeral river and does not have water flow along its entire reach except during very large wet cycles. With the exception of notably large wet cycles, the majority of the aquifer recharge within the Mojave River drainage system occurs along the upper reaches of the Mojave River and is less pronounced in the middle and lower reaches of the drainage system.

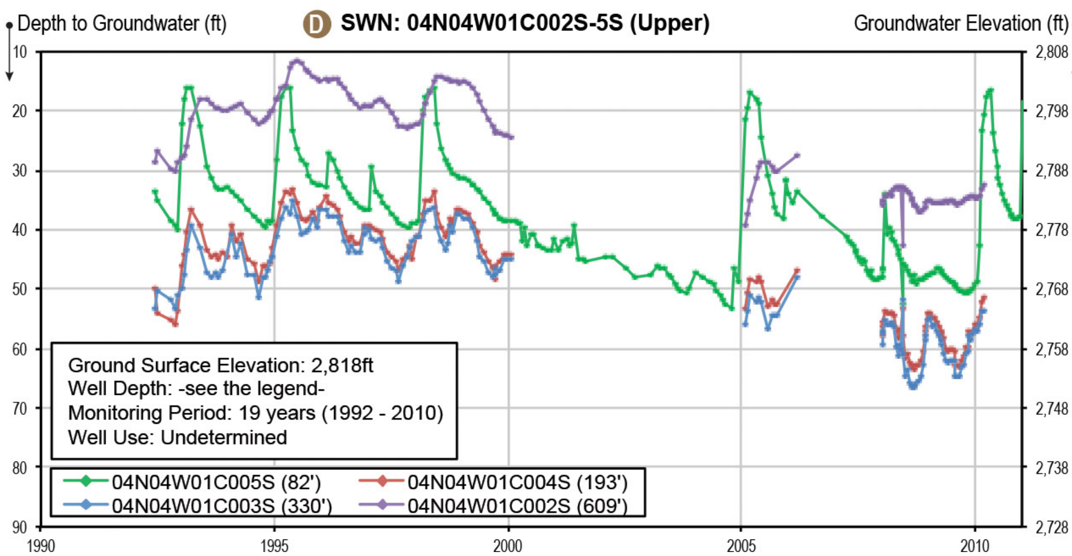


Prepared by California Department of Water Resources for California's Groundwater Update 2013

Figure 11-11 Groundwater Hydrographs for the South Lahontan Hydrologic Region, Page 2







Hydrograph 10N09W04D001S

Figure 11-11a is a hydrograph for Well 10N09W04D001S located north of Rogers Lake in the northeastern portion of the Antelope Valley Groundwater Basin (6-44). This hydrograph depicts a steady groundwater-level decline from 1960 to 1992. Following a brief rise in groundwater levels, the decline resumed from 1997 to 2010. This well is located within the Edwards Air Force Base boundary and is within 10 miles of a borax mine. The well completion depth is approximately 502 feet and is constructed within alluvium. The groundwater extracted by this well is likely confined by the lacustrine deposits exposed at the land surface near Rogers Lake (Leighton and Phillips 2003). The hydrograph for Well 10N09W04D001S displays groundwater levels measured monthly to quarterly from 1957 to 1968, then approximately semi-annually, in the spring and autumn, from 1969 to 2009. Beginning in 2010, the groundwater level was measured annually in the spring. The Antelope Valley Groundwater Basin is designated as a CASGEM high-priority groundwater basin.

Prior to 1972, more than 90 percent of the water demand in the Antelope Valley was met by groundwater. The estimated maximum annual groundwater extracted was 395 taf in 1952 (Leighton and Phillips 2003). The heavy reliance on groundwater in the valley caused the groundwater levels to decline, which led to increased pumping costs. In the 1960s and 1970s, the increased pumping costs resulted in declined agricultural production and an associated decrease in groundwater production (Antelope Valley Integrated Regional Water Management Plan 2007). In 1972, water from the SWP became available within Antelope Valley to reduce the reliance on groundwater. The Antelope Valley experienced rapid urban growth in the 1980s which resulted in a high water demand. The population in Antelope Valley increased by 330 percent from 1970 to 2005 (Antelope Valley Integrated Regional Water Management Plan, 2007). Since 1972, 50 percent to 90 percent of the total water demand has been met by groundwater production (Leighton and Phillips 2003).

The hydrograph for Well 10N09W04D001S shows that the groundwater level steadily declined from 1960 to 1992. The groundwater level rose from 1993 to 1996, but gradually declined from 1997 to 2010. The groundwater level in the well shows seasonal variation until 1992, but does not appear to be greatly affected by droughts or heavy precipitation years. The aquifers within Antelope Valley are primarily recharged at the alluvial fans of the San Gabriel and Tehachapi mountains. Infiltration from precipitation on the valley floor is negligible and does not contribute much water to the underlying aquifer systems (Leighton and Phillips 2003).

The long-term decline in groundwater levels has resulted in more than 6 feet of land subsidence and permanent loss of groundwater storage in some areas (Antelope Valley Integrated Regional Water Management Plan 2007). The long-term decline of groundwater levels in portions of the region has also led to litigation. The groundwater rights of residents and purveyors within the Antelope Valley region are currently undergoing an adjudication process overseen by the Superior Court of California. If the groundwater rights become adjudicated, the groundwater levels and extraction limits will be managed in a court-appointed manner with the goal of stabilizing groundwater levels and preventing further damage to the region from the long-term decline of groundwater levels (Antelope Valley Integrated Regional Water Management Plan 2007).

Hydrograph 09N02W02E001S

Figure 11-11b is a hydrograph for Well 09N02W02E001S located in the Lower Mojave River Valley Groundwater Basin (6-40), a CASGEM medium-priority basin. This hydrograph depicts the groundwater levels in the lower reaches of the Mojave River in response to precipitation events in the watershed. Well 09N02W02E001S is constructed adjacent to the Mojave River, north of Barstow. The surrounding land use includes residential developments, a railroad station, and a groundwater recharge pond which uses water from the SWP to replenish the underlying aquifers.

Hydrograph 09N03W23C001S

Figure 11-11c is a hydrograph for Well 09N03W23C001S located in the Middle Mojave River Valley Groundwater Basin (6-41), a CASGEM low-priority basin. The hydrograph depicts the aquifer response to periods of high and low precipitation in an arid environment. Well 09N03W23C001S is completed in the active portion of the Mojave River between the communities of Helendale and Lenwood. Agricultural developments and sparse residential developments are located in the general vicinity of the well.

Well 04N04W01C005S, in the Upper Mojave River Valley Groundwater Basin, responds rapidly to heavy precipitation years, as shown by the spike in groundwater levels in early 2010. There appears to be a delayed response between precipitation and the subsequent recharge to the aquifers in the Middle and Lower Mojave River Valley groundwater basins. The hydrographs for Wells 09N03W23C001S and Well 09N02W02E001S show similar characteristics. But the spike in groundwater levels in both wells is not observed until early 2011. The delayed recharge response may be the result of the Mojave River being an ephemeral river and not having water flow along its entire reach except during very wet cycles. The Mojave River channel and its underlying aquifer system contain very porous sediments which allow rapid water infiltration. With the exception of notably wet cycles, the majority of the aquifer recharge within the Mojave River drainage system occurs along the upper reaches of the Mojave River and is less pronounced in the middle and lower reaches of the drainage system. This preferential recharge in the upper reaches of the Mojave River drainage system can be seen in the hydrographs, as the groundwater levels become deeper toward the lower reaches of the drainage system.

The troughs, or downward trends, in the hydrographs correlate with droughts or periods of low precipitation. Notable droughts during the time span of the hydrographs occurred from 1999 to 2004, and 2007 to 2009. Although minor seasonal fluctuations can be seen, all three hydrographs display sharp downward trends during these droughts. The groundwater level decreases rapidly during years with little precipitation as groundwater is extracted, or as groundwater percolates deeper into the aquifer system, or migrates down-gradient as underflow. This indicates the groundwater resource in these basins is closely related to the local weather and dependent upon precipitation for recharge.

Hydrograph 04N04W01C002S to 04N04W01C005S

Figure 11-11d is a hydrograph for a nested-well cluster located in the Upper Mojave River Valley Groundwater Basin (6-42). The nested-well cluster is constructed in a residential and commercial area adjacent to the Mojave River in the city of Apple Valley. The total completion depth is 620 feet and consists of four wells: Well 04N04W01C002S (609 feet below ground surface

[bgs]), Well 04N04W01C003S (330 feet bgs), Well 04N04W01C004S (193 feet bgs), and Well 04N04W01C005S (82 feet bgs). Well 04N04W01C005S has the most continuous record of groundwater-level measurements. The groundwater-level measurements were recorded every few weeks from 1992 to 2006 and biweekly beginning in 2006. The groundwater levels in the other wells have been recorded nearly monthly from 1992 to 1999, in all of 2005, and then recorded biweekly beginning in 2008.

Well 04N04W01C005S displays the most groundwater-level fluctuation and the largest response to the recharge and drawdown events. The groundwater levels in Well 04N04W01C003S and Well 04N04W01C004S closely track and measure the hydraulic head from the same aquifer. Well 04N04W01C002S has a shallow depth to water that is caused by the reduced permeability of the deeper deposits, which likely represent localized semi-confined to confined conditions. (California Department of Water Resources 2003).

The groundwater levels depicted in each of the hydrographs for the Upper, Middle, and Lower Mojave River Valley groundwater basins display seasonal fluctuations in response to the weather. The spikes in the hydrographs correlate to periods of heavy precipitation which recharge the underlying aquifers and cause groundwater levels to rise. As displayed in most of the hydrographs, the years with relatively abundant precipitation include 1993, 1995, 1998, 2005, and 2010.

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 monitoring periods, by the overlying groundwater basin area, and by the estimated specific yield, or volume of pore space, from which water may be extracted.

Examining the annual change in groundwater in storage over a series of years helps identify aquifer response to changes in hydrology, land use, and groundwater management. If the volumetric change in storage is negligible over a period represented by average hydrologic and land use conditions, the basin is considered to be in equilibrium. But, declining groundwater levels and reduction of groundwater in 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 risks 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."

Change in groundwater in storage estimates for the groundwater basins within the South Lahontan region were not developed for *California Water Plan Update 2013*. Some local groundwater agencies within the South Lahontan region, including MWA, periodically develop change in groundwater in storage estimates for basins within their service area.

Groundwater Quality

The chemical character of groundwater in the South Lahontan region is variable, but often contains calcium or sodium bicarbonate. In basins with closed drainages, water character often changes from calcium-sodium bicarbonate near the margins of the basin, to sodium chloride or chloride sulfate beneath a dry lake. It is not uncommon for concentrations of dissolved constituents to rise dramatically toward a dry lake where saturation of mineral salts is reached. The total dissolved solids (TDS) content of groundwater is high in many of the basins in this region. Some of the contaminants affecting groundwater use in the region include arsenic, gross alpha particle activity, uranium, fluoride, TDS, and boron.

Several State and federal GAMA-related groundwater quality reports that help assess and outline the groundwater quality conditions for the South Lahontan region are listed in Table 11-9.

Table 11-9 GAMA Groundwater Quality Reports for the South Lahontan Hydrologic Region

Data Summary Reports
• Borrego Valley, Central Desert, and Low-Use Basins http://pubs.usgs.gov/ds/659
• Owens Valley and Indian Wells Valley http://www.waterboards.ca.gov/gama/docs/dsr_owensindianwells.pdf
• Mojave Valley http://www.waterboards.ca.gov/gama/docs/mojave_dsr.pdf
• Antelope Valley http://www.waterboards.ca.gov/gama/docs/antlpvlly_data.pdf
Assessment Reports
• Status of Groundwater Quality in the California Desert Region, 2006-2008: California GAMA Priority Basin Project http://pubs.usgs.gov/sir/2012/5040/pdf/sir20125040.pdf
Fact Sheets
• Groundwater Quality in the Antelope Valley http://pubs.usgs.gov/fs/2012/3033/pdf/fs20123033.pdf
• Groundwater Quality in the Indian Wells Valley http://pubs.usgs.gov/fs/2012/3035/pdf/fs20123035.pdf
• Groundwater Quality in the Mojave Area http://pubs.usgs.gov/fs/2012/3036/pdf/fs20123036.pdf
• Groundwater Quality in the Owens Valley http://pubs.usgs.gov/fs/2012/3032/pdf/fs20123032.pdf
Domestic Well Project
• No counties in this region have been sampled by this program.
Other Relevant Reports
• Communities that Rely on a Contaminated Groundwater Source for Drinking Water http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/index.shtml

Note:
GAMA = Groundwater Ambient Monitoring and Assessment Program

Groundwater Quality at Community Drinking Water Wells

The SWRCB recently completed a report to the legislature, titled *Communities that Rely on a Contaminated Groundwater Source for Drinking Water*. The report focused on chemical contaminants found in active groundwater wells used by CWSs. A CWS is defined under the California Health and Safety Code (Section 116275) as a "public water systems that serves at least 15 service connections used by yearlong residents or regularly serve at least 25 yearlong residents of the area served by the system." A CWS serves the same group of people, year round, from the same group of water sources. The findings of this report reflect raw untreated groundwater quality and do not necessarily reflect the final quality of groundwater delivered to these communities.

In the South Lahontan region, there are an estimated 185 CWSs, with an estimated 636 active CWS wells. Table 11-10 shows that 180 of the 636 CWS wells (28 percent) are identified as being affected by chemical contaminants that exceed an MCL. The affected wells are used by 73 CWSs in the region. Fifty-four of the 73 affected CWSs serve small communities which commonly require financial assistance to construct water treatment facilities or alternative solutions to meet drinking water standards (Table 11-11). The most prevalent groundwater contaminants affecting community drinking water wells in the region include gross alpha particle activity, uranium, arsenic, and fluoride (Table 11-12). In addition, 46 wells are affected by multiple contaminants.

While most large CWSs are able to remove or reduce groundwater contaminants below drinking water standards, small CWSs often have difficulty accomplishing this, and some are unable to provide drinking water that meets primary drinking water standards. As of February 2013, there were 54 small CWSs in the South Lahontan region that violate a primary drinking water standard, primarily because of groundwater contaminants. Forty-one of these small CWSs are affected by arsenic (California Department of Public Health 2013).

Table 11-10 Community Drinking Water Wells that Exceed a Primary Maximum Contaminant Level Prior to Treatment in the South Lahontan Hydrologic Region

Well Information	Community Water System[a] Wells
Number of Affected Wells[b]	180
Total Wells in the Region	636
Percentage of Affected Wells[b]	28%

Source: State Water Resources Control Board's report to the Legislature, *Communities that Rely on a Contaminated Groundwater Source for Drinking Water* (2013).
Notes:
[a]Community water system means a public water system that serves at least 15 service connections used by year-long residents or regularly serves at least 25 year-long residents of the areas served by the system (Health and Safety Code Section 116275).
[b]Affected wells exceeded a primary maximum contaminant level prior to treatment at least twice from 2002 to 2010. Gross alpha levels were used as a screening assessment only and did not consider uranium correction.

Table 11-11 Community Drinking Water Systems that Rely on Contaminated Groundwater Wells in the South Lahontan Hydrologic Region

System Information	Community Water Systems[a]		
	Number of Affected Water Systems[b]	Total Water Systems in the Region	Percentage of Affected Water Systems[b]
Small Systems Population ≤ 3,300	54	154	35%
Medium Systems Population 3,301 – 10,000	10	13	77%
Large Systems Population > 10,000	9	18	50%
Total	**73**	**185**	**39%**

Source: State Water Resources Control Board's report to the Legislature, *Communities that Rely on a Contaminated Groundwater source for Drinking Water* (2013).

Notes:
[a]Community water system means a public water system that serves at least 15 service connections used by year-long residents or regularly serves at least 25 year-long residents of the areas served by the system (Health and Safety Code Section 116275).
[b]Affected water systems are those with one or more wells that exceed a primary maximum contaminant level prior to treatment at least twice from 2002 to 2010. Gross alpha levels were used as a screening assessment only and did not consider uranium correction.
State small water systems are not included in the above totals. These systems serve 5 to 14 service connections and do not regularly serve water to more than 25 people. In general, state small water systems are regulated by local county environmental health departments.

Table 11-12 Contaminants Affecting Community Drinking Water Systems in the South Lahontan Hydrologic Region

Principal Contaminant (PC)	Number of Affected Water Systems[b] (PC exceeds the Primary MCL)	Number of Affected Wells[c,d,e] (PC exceeds the Primary MCL)
Arsenic	41	119
Gross Alpha Particle Activity	28	50
Uranium	13	30
Fluoride	9	17
Nitrate	6	6
Aluminum	2	2
Perchlorate	1	2
Antimony	1	1
Di(2-ethylhexyl)phthalate (DEHP)	1	1

Source**:** State Water Resources Control Board's report to the Legislature, *Communities that Rely on Contaminated Groundwater* (2013).

Notes:
MCL = maximum contaminant level (State and/or federal)
[a]Community water system means a public water system that serves at least 15 service connections used by year-long residents or regularly serves at least 25 year-long residents of the areas served by the system (Health and Safety Code Section 116275).
[b]Affected water systems are those with one or more wells that exceed a primary maximum contaminant level prior to treatment at least twice from 2002 to 2010. Gross alpha levels were used as a screening assessment only and did not consider uranium correction.
[c]Affected wells exceeded a primary maximum contaminant level prior to treatment at least twice from 2002 to 2010. Gross alpha levels were used as a screening assessment only and did not consider uranium correction.
[d]Forty-four wells are affected by two contaminants.
[e]Two wells are affected by three contaminants.

Chromium VI is another groundwater contaminant that is expected to affect many community water systems when a State MCL is adopted by CDPH. In 2011, the State Office of Environmental Health Hazard Assessment set a public health goal for chromium VI at 0.02 parts per billion (ppb). Chromium VI is found to occur naturally in the environment at low levels, but there are also areas of contamination in the state caused by historic industrial use, such as manufacturing of textile dyes, wood preservation, leather tanning, and anti-corrosion coatings (California Department of Public Health 2012). The SWRCB's report indicated that 1,378 of the 8,396 active CWS wells had two or more detections for chromium VI above 1 ppb. When the chromium VI MCL is implemented, it is expected to affect many California water systems.

Groundwater Quality at Domestic Wells

Private domestic wells are typically used by either single family homeowners or other groundwater-reliant systems that are not regulated by the State. Domestic wells generally tap shallower groundwater, making them more susceptible to contamination. Many domestic well owners are unaware of the quality of the well water because the State does not require 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.

To date, the GAMA Domestic Well Project has not sampled private domestic wells in the five counties that are part of the South Lahontan region.

Groundwater Quality — GAMA Priority Basin Project

The GAMA Priority Basin Project was initiated to provide a comprehensive baseline of groundwater quality in the State, and assess deeper groundwater basins that account for more than 95 percent of all groundwater used for public drinking water supply. The GAMA Priority Basin Project is grouped into 35 groundwater basin groups statewide called "study units," and is being implemented by SWRCB, USGS, and LLNL.

The GAMA Priority Basin Project tests for constituents that are a concern in public supply wells. The list of constituents includes:

- Field parameters.
- Organic constituents.
- Pesticides.
- Constituents of special interest.
- Inorganic constituents.
- Radioactive constituents.
- Microbial constituents.

For the South Lahontan region, USGS has completed data summary reports for the following study units:

- Low-Use Basins of the Mojave and Sonoran deserts.
- Owens and Indian Wells valleys.
- Mojave.
- Antelope Valley.

These study units are all in the South Lahontan region with the exception of the Low-Use Basins of the Mojave and Sonoran deserts, which includes wells in both the South Lahontan and Colorado River regions.

For comparison purposes only, groundwater quality results from these data summary reports were compared against public drinking water standards established by CDPH and/or the U.S. Environmental Protection Agency. These standards included MCLs, secondary maximum contaminant levels (SMCLs), notification levels (NLs), and lifetime health advisory levels (HALs). A summary of untreated groundwater quality results for these study units is listed in Table 11-13. In addition to these data summary reports, USGS has completed assessment reports and fact sheets for the South Lahontan region. They are listed in Table 11-8.

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 (SNMPs) for every groundwater basin/sub-basin in California. Each plan must include monitoring, source identification, and implementation measures.

Throughout the South Lahontan region, participating in the development of SNMPs is of paramount importance to improve water quality in the region and provide for a sustainable economic and environmental future. The Lahontan RWQCB is working with partners and stakeholders to develop SNMPs for 12 priority groundwater basins, with five located in the northern part of the North Lahontan region and seven in the South Lahontan region. The Lahontan RWQCB will be collaborating with IRWM groups, and affected stakeholders, to develop SNMPs for Antelope, Mojave Valley (Lower, Middle and Upper) , Owens Valley, Indian Wells Valley, Fremont Valley, and Tehachapi Valley East groundwater basins.

Table 11-13 Groundwater Quality Results from GAMA Data Summary Reports from GAMA Summary Reports for the South Lahontan Hydrologic Region

Constituent	Health Based Threshold	Number of Detections Greater Than Health Based Threshold			
		Desert Low-Use Basins[a]	Owens/Indian Wells Valleys Study Unit	Mojave Study Unit	Antelope Valley Study Unit
Number of Wells		18	95	59	57
Inorganic Constituents					
Arsenic	MCL	5	11	9	5
Boron	NL	3	13	2	1
Fluoride	MCL	5	5	3	
Molybdenum	HAL	4	4	1	
Nitrate	MCL	-	-	-	1
Nitrite + Nitrate	MCL	1	-	-	-
Strontium	HAL	-	1	1	-
Uranium	MCL	1	4	1	-
Vanadium	NL	-	1	2	2
Organic Constituents					
VOCs	MCL	-	-	-	-
Pesticides	MCL	-	-	-	-
Constituents of Special Interest					
Perchlorate	MCL	-	-	-	-
NDMA	NL	-	-	1	-
1,2,3 TCP	NL	-	-	-	-
Radioactive Constituents					
Gross Alpha	MCL	2	-	2	2
Secondary Standards					
Chloride[b]	SMCL	1	5	1	1
Iron	SMCL	-	3	-	-
Manganese	SMCL	1	13	1	-
Sulfate[b]	SMCL	2	1	5	3
Total Dissolved Solids[b]	SMCL	9	17	7	4

Sources:
U.S. Geological Survey report, *Ground-water Quality Data in the Borrego Valley, Central Desert, and Low-Use Basins of the Mojave and Sonoran Deserts Study Unit 2008–2010*; U.S. Geological Survey report, *Ground-Water Quality Data in the Owens and Indian Wells Valleys Study Unit, 2006*; U.S. Geological Survey report, *Ground-Water Quality Data for the Mojave Study Unit, 2008*; U.S. Geological Survey report, *Ground-Water Quality Data in the Antelope Valley Study Unit, 2008.*

Notes:
GAMA = Groundwater Ambient Monitoring and Assessment Program, HAL = lifetime health advisory level (U.S. Environmental Protection Agency), MCL = maximum contaminant level (State and/or federal), NL = notification level (State), SMCL = secondary maximum contaminant level (State), TDS = total dissolved solids, VOC = volatile organic compound

[a]Low-use basin area includes 29 wells in the Colorado River and South Lahontan hydrologic regions. Eighteen wells are in the South Lahontan Hydrologic Region (U.S. Geological Survey report Figures 5A – 5D).

[b]Wells that exceed secondary maximum contaminant levels for chloride, sulfate, and, total dissolved solids are greater than recommended levels.

Land Subsidence

In the South Lahontan region, researchers have investigated the occurrence of land subsidence in the Mojave Desert and at two locations in the Antelope Valley. Groundwater is the primary source of water supply in the Mojave Desert. Groundwater production initially developed along the Mojave River in the early 1900s. By the mid-1950s, long-term overdraft was recognized to have commenced (Mojave Water Agency 2004). Groundwater levels have declined by about 40 feet to more than 100 feet in some areas since the 1930s (Smith et al. 2011). The USGS and MWA worked cooperatively to investigate the occurrence of land subsidence in four areas of MWA management area (Sneed et al. 2003). Sneed et al. (2003) determined that subsidence, ranging from 0.15 foot to 0.3 foot, occurred in four areas of the Mojave Desert: El Mirage, Lockhart-Harper Lake, Newberry Springs, and Lucerne Valley.

MWA is the largest local groundwater management agency in the Mojave Desert and serves as watermaster for the areas specified in the 1996 Mojave Basin Area judgment. MWA recognizes the potential for future land subsidence and has developed water management objectives to reduce the potential for land subsidence. The objectives include balancing water demand and supply, and stabilizing groundwater storage (Mojave Water Agency 2004).

The Antelope Valley has had a long history of groundwater production. By 1908, settlers had drilled more than 300 wells in the lower part of the valley where shallow artesian conditions existed. Because of unreliable and unstable surface-water sources, agricultural developments began relying on groundwater in 1912. Agricultural developments continued to increase and peaked during the 1950s. In the early 1960s, the predominant water demand began to shift from agriculture to municipal and industrial developments (Galloway et al. 1998). The water demand in the Antelope Valley was met almost entirely by groundwater until 1972, when water transported by the SWP became available for import. During the 1980s, the Antelope Valley experienced rapid urban growth which resulted in a high water demand and subsequent decline in groundwater levels. Groundwater levels have declined at least 100 feet in most of the Antelope Valley region and resulted in land subsidence in some areas (Antelope Valley Integrated Regional Water Management Plan 2007).

Land subsidence has been a known occurrence in the Antelope Valley area since the 1950s (Antelope Valley Integrated Regional Water Management Plan 2007). Lancaster is the largest city in the Antelope Valley, with an estimated population of 157,700 (U.S. Census Bureau 2011). Phillips et al. (2003) investigated the amount of land subsidence in the Lancaster area using GPS surveys, tilt-meters, and a dual borehole extensometer. The study indicated that more than 6 feet of land subsidence in Lancaster was the result of groundwater levels having declined by more than 200 feet since the 1920s (Phillips et al. 2003).

Sneed and Galloway (2000) investigated land subsidence at Edwards Air Force Base, north of Lancaster. Sneed and Galloway (2000) found that long-term groundwater extractions resulted in nearly 4 feet of land subsidence between 1926 and 1992 at Edwards Air Force Base. From 1990 to 2000, nearly 0.4 foot of subsidence occurred (Sneed and Galloway 2000). Surface deformations related to land subsidence at Edwards Air Force Base include fissures, cracks, and depressions on Rogers (Dry) Lake. The fissures range from 1 inch to more than 1 foot wide and can be as long as 700 feet (Antelope Valley Integrated Regional Water Management Plan 2007). The deformation has affected the use of the lakebed as a runway for aircraft and space shuttles (Phillips et al. 2003). Other effects associated with land subsidence in the Antelope Valley include altered drainage gradients, increased flooding and erosion, failed well casings, and damage to roads and at least one structure (Antelope Valley Integrated Regional Water Management Plan 2007).

Current water management efforts in the Antelope Valley include the use of imported surface water from the SWP, the storage of local runoff in Little Rock Reservoir, artificial recharge, the use of recycled water, and conservation. The Antelope Valley region is currently undergoing an adjudication process which began in 1999. If the California Superior Court adjudicates the groundwater rights, the judgment will likely stipulate groundwater extraction rights and limits.

The population growth in the Antelope Valley is expected to continue, and the forecasted water demand is expected to exceed currently available water supplies (Antelope Valley Integrated Regional Water Management Plan 2007). Groundwater modeling by Phillips et al. (2003) suggests that land subsidence would likely continue if groundwater levels continue to decline.

Groundwater Management

In 1992, the California 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 118-2003, 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, enacted legislation includes SB 1938, AB 359, and provisions of SB X7-6 and AB 1152. These significant pieces of legislation establish 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. AB 359, introduced in 2011, made changes to the California Water Code that 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 a result, 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. Agricultural 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. Because of 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 step toward sustainable management of this valuable resource.

DWR's Groundwater Web site (http://water.ca.gov/groundwater/) has the latest information on California's groundwater management planning efforts. It includes a summary of the Sustainable Groundwater Management Act enacted in September 2014. The Sustainable Groundwater Management Act, a three-bill legislative package, includes the provisions of SB 1168 (Pavley), AB 1739 (Dickinson), and SB 1319 (Pavley). The act mandates 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 of the act are based on the required, voluntary, and recommended groundwater management components assessed in the following sections.

The following sections provide an inventory and assessment of GWMPs, groundwater basin adjudications, county ordinances, and other groundwater planning activities in the South Lahontan region.

Groundwater Management Plan Inventory

Groundwater management information included in this chapter is based on GWMP 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 the groundwater basins the plans cover. The inventory also provides the number of GWMPs developed based on AB 3030 (1992) and the number developed or updated to meet the additional groundwater management requirements associated with the SB 1938 (2002).

The South Lahontan region includes 14,800 square miles of alluvial groundwater basins recognized by Bulletin 118-2003. Figure 11-12 shows the location and distribution of the GWMPs within the South Lahontan region and indicates pre- and post-SB 1938 GWMPs. Table 11-14 lists the results of the GWMP inventory for the region by adopting agency, signatories, plan date, and groundwater basin.

There are four submitted GWMPs in the South Lahontan region. They represent 28 percent of the alluvial groundwater basin area within the region. Three of the four GWMPs are fully contained within the South Lahontan region, with one plan including portions of the adjacent Colorado River Hydrologic Region. All four GWMPs cover areas overlying alluvial groundwater basins identified in Bulletin 118-2003. One plan also includes areas not identified in Bulletin 118-2003. One of the plans is a water management plan that includes surface-water management and meets the requirements of a GWMP. Collectively, the four GWMPs cover 5,200 square miles. Of that area, about 4,100 square miles fall within Bulletin 118-2003 alluvial groundwater basins.

The inventory and assessment of GWMPs in the South Lahontan region determined that three of the plans have been developed or updated to include the SB 1938 requirements and are considered "active" for the purposes of the GWMP assessment. The three GWMPs also cover four of the five basins identified as high or medium priority under the CASGEM Basin Prioritization project. These priority basins account for about 94 percent of the population that overlies the basins and about 55 percent of groundwater use for the region.

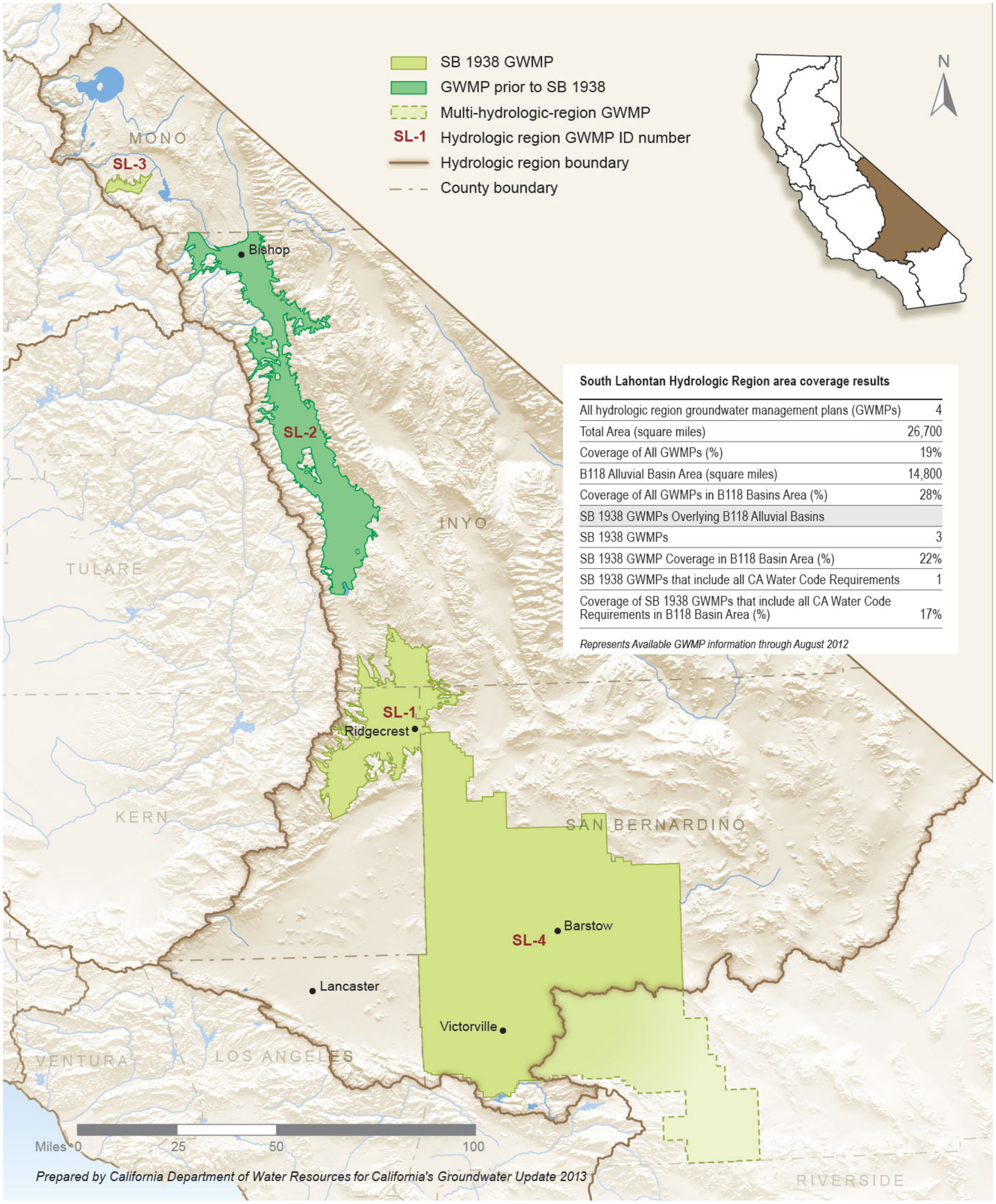
Table 11-14 Groundwater Management Plans in the South Lahontan Hydrologic Region

Map Label	Agency Name	Date	County	Basin Number	Basin Name
SL-1	**Indian Wells Valley Water District**	2006	Kern, Inyo, San Bernardino	6-53	Coso Valley
	Naval Air Weapons Station / China Lake			6-54	Indian Wells Valley
	North American Chemical Company				
	City of Ridgecrest				
	Kern County Water Agency				
	Inyokern Community Services District				
	Indian Wells Valley Airport District				
	Eastern Kern County Resources Conservation District				
	Ridgecrest Resource Area Bureau of Land Management				
	Quist Farms				
SL-2	**Inyo County and City of Los Angeles**	1990	Inyo	6-12	Owens Valley
	No signatories on file				
SL-3	**Mammoth Community Water District**	2005	Mono	6-11	Long Valley
	No signatories on file				
SL-4	**Mojave Water Agency**	2004	San Bernardino, Kern, Los Angeles	6-35	Cronise Valley
	No signatories on file			6-38	Caves Canyon Valley

Map Label	Agency Name	Date	County	Basin Number	Basin Name
				6-40	Lower Mojave River Valley
				6-41	Middle Mojave River Valley
				6-42	Upper Mojave River Valley
				6-44	Antelope Valley
				6-46	Fremont Valley
				6-48	Goldstone Valley
				6-49	Superior Valley
				6-50	Cuddeback Valley
				6-51	Pilot Knob Valley
				6-52	Searles Valley
				6-53	Salt Wells Valley
				6-54	Indian Wells Valley
				6-77	Grass Valley
				6-89	Kane Wash Area
				7-11	Copper Mountain Valley
				7-12	Warren Valley
				7-13.01	Deadman Lake Subbasin
				7-13.02	Surprise Spring Subbasin
				7-15	Bessemer Valley
				7-16	Ames Valley
				7-18.01	Soggy Lake Subbasin
				7-18.02	Upper Johnson Valley Subbasin
				7-19	Lucerne Valley
				7-20	Morongo Valley
				7-50	Iron Ridge Area
				7-51	Lost Horse Valley
				7-62	Joshua Tree

Note:
Table reflects plans received by August 2012.

Figure 11-12 Groundwater Management Plans in the South Lahontan Hydrologic Region



South Lahontan Hydrologic Region area coverage results

All hydrologic region groundwater management plans (GWMPs)	4
Total Area (square miles)	26,700
Coverage of All GWMPs (%)	19%
B118 Alluvial Basin Area (square miles)	14,800
Coverage of All GWMPs in B118 Basins Area (%)	28%
SB 1938 GWMPs Overlying B118 Alluvial Basins	
SB 1938 GWMPs	3
SB 1938 GWMP Coverage in B118 Basin Area (%)	22%
SB 1938 GWMPs that include all CA Water Code Requirements	1
Coverage of SB 1938 GWMPs that include all CA Water Code Requirements in B118 Basin Area (%)	17%

Represents Available GWMP information through August 2012

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 water management, and water banking practices. The survey also intended to build a better understanding of existing groundwater management efforts in California. In addition to the information gleaned from the DWR/ACWA groundwater management survey, DWR independently reviewed the GWMPs to assess the following information:

- How many of the post-SB 1938 GWMPs meet the six required components included in SB 1938 and incorporated into California Water Code Section10753.7.
- 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 118-2003.

Groundwater management planning information collected through the DWR/ACWA survey and through DWR's assessment is not intended to be punitive in nature. It is widely understood that the application of effective groundwater management in California is rife 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 to coordinate with local agencies to expand groundwater data collection, management, and planning activities that promote effective 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.

Information associated with the GWMP assessment is based on data that were readily available or received 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 the GWMP assessment effort conducted as part of *California Water Plan Update 2013*. The following information will only address the active plans that were determined by DWR to meet some or all of the SB 1938 requirements.

Required GWMP Components

California Water Code Section 10753.7 requires that six components be included in a GWMP 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**: Basin management objectives (BMOs) include components relating to the monitoring and managing of groundwater levels in 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. BMOs also include 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 DWR's Bulletin 118-2003, 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 118-2003 alluvial groundwater basins will incorporate the above components and shall use geologic and hydrologic principles appropriate to those areas.

Three of the six components contain required subcomponents that were also evaluated. The requirement to develop a map of recharge areas was not required until January 1, 2013; consequently, the requirement was not evaluated. The requirement for local agencies located outside a Bulletin 118-2003 groundwater basin was not applicable for any of the GWMPs in the South Lahontan region.

DWR determined that one out of the three active GWMPs incorporated all of the required components evaluated. Table 11-15 identifies the percentage of the three active plans that meet the required components and subcomponents of California Water Code 10753.7. A detailed description of the individual component assessment is provided in the following paragraphs.

Basin Management Objectives

The BMOs assessment consisted of four required subcomponents that 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–groundwater interaction.

The assessment indicated that one of the three GWMPs met the overall BMO requirement by providing measurable objectives and actions that will occur when specific conditions are met for each of the BMO subcomponents. Two GWMPs did not meet the overall BMO component, one GWMP contained the required information for three of the four BMO subcomponents, and one GWMP contained the required information for two of the four BMO subcomponents. As a result, two GWMPs were found to be in partial compliance.

Table 11-15 Assessment for GWMP Requirement Components in the South Lahontan Hydrologic Region

Senate Bill 1938 Required Components	Percentage of Plans that Meet Requirement
Basin Management Objectives	33%
BMO: Monitoring/Management Groundwater Levels	100%
BMO: Monitoring Groundwater Quality	100%
BMO: Inelastic Subsidence	33%
BMO: SW/GW Interaction and Affects to Groundwater Levels and Quality	67%
Agency Cooperation	100%
Map	67%
Map: Groundwater Basin Area	100%
Map: Area of Local Agency	100%
Map: Boundaries of other Local Agencies	67%
Recharge Areas (January 1, 2013)	Not Assessed
Monitoring Protocols	33%
MP: Changes in Groundwater Levels	100%
MP: Changes in Groundwater Quality	100%
MP: Subsidence	33%
MP: SW/GW Interaction and Affects to Groundwater Levels and Quality	67%
Met all Required Components and Subcomponents	**33%**

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

The BMO subcomponents that were not addressed in the partially compliant GWMPs were the planning requirements for the monitoring and management of inelastic land subsidence, and the interaction of surface water and groundwater.

Mapping

The mapping requirement of SB 1938 has three subcomponents. The GWMPs are required to provide: (1) one or more maps which depict the GWMP area, (2) the associated Bulletin 118-2003 groundwater basin(s), and (3) all neighboring agencies located within the basin(s). The GWMP assessment determined that two of the three GWMPs met all three of the requirements for mapping.

Monitoring Protocols

The monitoring protocol component consists of four subcomponents. In accordance with 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–groundwater interaction.

The overall results of the assessment for the monitoring protocols component are similar to the BMO component. The monitoring protocols assessment determined that one of three GWMPs met each of the required monitoring protocol subcomponents. The GWMPs which did not meet all of the BMO subcomponents lacked monitoring protocols for inelastic land subsidence and the interaction of surface water and groundwater levels, and how they relate to water quality and groundwater pumping.

Voluntary GWMP Components

In addition to the six required components, California Water Code Section 10753.8 provides a list of 12 components that may be included in a GWMP. The voluntary components include the following:

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.

The percentage of GWMPs in the South Lahontan region that included the voluntary components is shown in Table 11-16. The assessment of some voluntary components was expanded to include subcomponents, which aided in determining a level of inclusion, but reporting was not done on a subcomponent level. In many cases, if the plan included one of more of the subcomponents, the plan was considered to fully meet the voluntary component.

Table 11-16 shows that all three of the GWMPs in the South Lahontan region included the voluntary components that involve conjunctive use operations, groundwater extraction and replenishment, groundwater monitoring, overdraft, and regulatory agencies. Two of the GWMPs included the voluntary components relating to construction and operation, groundwater contamination, well abandonment and destruction, well construction policies, wellhead protection and recharge, and land use. The control of saline intrusion was only included in one GWMP.

Table 11-16 Assessment of GWMP Voluntary Components in the South Lahontan Hydrologic Region

Voluntary Components	Percentage of Plans that Include Component
Saline Intrusion	33%
Wellhead Protection and Recharge	67%
Groundwater Contamination	67%
Well Abandonment and Destruction	67%
Overdraft	100%
Groundwater Extraction and Replenishment	100%
Monitoring	100%
Conjunctive Use Operations	100%
Well Construction Policies	67%
Construction and Operation	67%
Regulatory Agencies	100%
Land Use	67%

Note:
Table reflects assessment results of Senate Bill 1938 plans received by August 2012.

Many GWMP projects can take years to plan, fund, and implement. Continuing to update GWMPs with newly required component activities can be time consuming and expensive. Based on DWR's discussions with a several GWMP entities around the state, it was apparent that agencies do not regularly update their GWMPs as new projects are implemented. As a result, it is likely that the construction and operation of newly developed projects have not been listed in the most recent GWMP document.

In summary, only one of the three GWMPs in the South Lahontan region incorporated all 12 of the voluntary components. One plan incorporated 11 of the voluntary components, and one plan incorporated seven of the voluntary components.

GWMP Components Recommended by Bulletin 118-2003

Bulletin 118-2003, Appendix C provides a list of seven recommended components related to management development, implementation, and evaluation of a GWMP that should be considered to help ensure effective and sustainable groundwater management. The recommended components include:

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 11-17 identifies the percentage of the active GWMPs in the South Lahontan region that include the seven recommended suggestions outlined in Bulletin 118-2003. Results from the GWMP assessment determined that three of the four GWMPs discussed IRWM planning and participation, creating an advisory committee to guide the GWMP implementation, and performing periodic GWMP evaluation. Two of the three GWMPs included plans for GWMP implementation. They discussed the BMOs and how each of the adopted management objectives helps to attain their goals, and they described how current and planned actions by the managing entity will help meet the adopted management objectives. Two of the plans did not include a monitoring plan description with a map of monitoring sites and site-specific information.

In summary, two of the three GWMPs in the South Lahontan region incorporated six of the seven components recommended in Bulletin 118-2003, and one GWMP incorporated three of the seven recommended components.

Table 11-17 Assessment of DWR Bulletin 118-2003 Recommended Components in the South Lahontan Hydrologic Region

Recommended Components	Percentage of Plans that Include Component
GWMP Guidance	100%
Management Area	67%
BMOs, Goals, and Actions	67%
Monitoring Plan Description	33%
IRWM Planning	100%
GWMP Implementation	67%
GWMP Evaluation	100%

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

DWR/ACWA Survey — Key Factors for Successful GWMP Implementation

The survey respondents were asked to provide feedback on which components helped make their GWMP implementation successful. The participants were asked to provide additional insights and list additional components, but not to rank their responses in terms of importance. Four agencies from the South Lahontan region participated in the survey. Table 11-18 is a summary of the individual responses for the four agencies.

Data collection, in formation sharing, developing an understanding of common interest, and stakeholder participation were reported as important components to their groundwater management planning successes. Having adequate surface-water supplies, as well as adequate storage and infrastructure systems, were also deemed important. In addition, sufficient funding

Table 11-18 Survey Results for Key Components Contributing to Successful GWMP Implementation in the South Lahontan Hydrologic Region

Key Components that Contributed to Success	Respondents
Sharing of Ideas and Information with other Water Resource Managers	4
Data Collection and Sharing	4
Adequate Surface Water Supplies	2
Adequate Regional and Local Surface Storage and Conveyance Systems	2
Outreach and Education	4
Developing an Understanding of Common Interest	4
Broad Stakeholder Participation	3
Water Budget	4
Funding	4
Time	3

Note:
Results from an online survey sponsored by the California Department of Water Resources and conducted by the Association of California Water Agencies — 2011 and 2012.

and time necessary to develop a GWMP were indicated as factors important to success. Broad stakeholder participation, having adequate time, having adequate surface-water supplies, and surface storage and conveyance systems were also identified as important factors. Further research is needed to better understand the key factors that contribute to successful implementation of effective groundwater management.

DWR/ACWA Survey — Key Factors Limiting GWMP Success

Survey participants were also asked to identify key factors they felt impeded implementation of their local GWMP. Table 11-19 indicates limited funding was an impediment to the success of groundwater planning. Funding is a challenging factor for many local agencies because the implementation and the operation of groundwater management projects are typically expensive and because the sources of funding for projects are typically limited to either locally raised funds or to grants from State and federal agencies. The survey respondents identified unregulated groundwater pumping, the lack of broad stakeholder participation, lack of governance, lack of surface storage and conveyance, lack of groundwater, and a lack of knowledge regarding local issues as factors that impede the successful implementation of GWMPs. Further research is needed to understand the extent to which these limitations affect implementation of effective groundwater management.

DWR/ACWA Survey — Opinions of Groundwater Sustainability

Finally, the survey asked if the respondents were confident in the long-term sustainability of their current groundwater supply. All four respondents felt long-term sustainability of their groundwater supply was possible.

Table 11-19 Survey Results for Factors that Limited the Successful GWMP Implementation in the South Lahontan Hydrologic Region

Limiting Factors	Respondents
Participation Across a Broad Distribution of Interests	2
Data Collection and Sharing	-
Funding for Groundwater Management Planning	3
Funding for Groundwater Management Projects	4
Funding to Assist in Stakeholder Participation	-
Understanding of the Local Issues	1
Outreach and Education	-
Groundwater Supply	2
Surface Storage and Conveyance Capacity	1
Access to Planning Tools	-
Unregulated Pumping	3
Lack of Governance	1

Note:
Results from an online survey sponsored by the California Department of Water Resources and conducted by the Association of California Water Agencies — 2011 and 2012.

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 v. 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 and regulate groundwater. Since 1995, the *Baldwin v. Tehama County* decision has remained untested. As a result, the precise nature and extent of the authority of cities and counties to regulate groundwater is still uncertain.

There are a number of groundwater ordinances that have been adopted by counties in the South Lahontan region. The most common ordinances are associated with groundwater wells. These ordinances regulate water transfers and well construction, and abandonment and destruction of wells. But none of the ordinances provide for comprehensive groundwater management. Table 11-20 lists the ordinances adopted in the South Lahontan region.

Special Act Districts

Greater authority to manage groundwater has been granted to a few local agencies 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.

Table 11-20 Groundwater Ordinances for the South Lahontan Hydrologic Region

County	Groundwater Management	Export Permits	Recharge	Well Abandonment and Destruction	Well Construction Policies
Inyo	-	Yes	-	Yes	Yes
Kern	-	Yes	-	-	Yes
Los Angeles	-	-	Yes	-	-
Mono	Yes[a]	Yes	-	Yes	Yes
San Bernardino	Yes[a]	-	-	Yes	Yes

Notes:
[a]Provide protection against exceeding the safe yield of a groundwater basin and the impacts associated with exceeding the safe yield.
Table represents information as of August 2012.

There are many special act districts established by the Legislature consisting of different authorities that may or may not have groundwater management authority. It was not part of the scope for *California Water Plan Update 2013* to identify individual types of special act districts or provide a listing of the established agencies. This chapter includes the GWMPs that were produced by these agencies and submitted to DWR, as discussed in the previous section.

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.

There are currently 24 groundwater adjudications in California. The South Lahontan region contains two of those adjudications. Table 11-21 provides a list of the adjudications. Figure 11-13 shows the location of groundwater adjudications in the South Lahontan region.

The Mojave Groundwater Basin adjudication judgment was finalized in 1996. The Superior Court appointed MWA to serve as the watermaster to ensure that the conditions set forth in the adjudication are followed. The judgment established free production allowance (FPA) for the water producers, which is the amount of water that a producer can pump for free during a year without having to pay for replacement water. A producer who needs more FPA than its assigned value must pay for the excess water by arranging to transfer the desired amount from another producer, or by buying the required amount from the watermaster. As indicated in Table 11-21, seven Bulletin 118-2003 groundwater basins in the South Lahontan region are included in this adjudication.

The adjudication for the Tehachapi Basin extends into the Tulare Lake Hydrologic Region. It was adjudicated in 1971.

Figure 11-13 Groundwater Adjudications in the South Lahontan Hydrologic Region

Table 11-21 Groundwater Adjudications in the South Lahontan Hydrologic Region

ID	Court Judgment	Basin Number	Basin Name	County	Judgment Date
A-18	Tehachapi Basin	6-45	Tehachapi Valley – East Basin	Kern	1971
A-8	Mojave Basin Area	6-37 6-40 6-41 6-42 6-43 6-47 6-89	Coyote Lake Valley Basin Lower Mojave River Valley Basin Middle Mojave River Valley Basin Upper Mojave River Valley Basin El Mirage Valley Basin Harper Valley Basin Kane Wash Area Basin	San Bernardino	1996

Note:
Table represents information as of April 2013.

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, 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. A few IRWM plans actively manage groundwater. Efforts by these IRWM RWMGs include creating groundwater contour maps for basin operations criteria, monitoring groundwater elevations, and monitoring groundwater quality.

There are five IRWM regions covering a portion of the South Lahontan region. Four regions have adopted IRWM plans and one region is currently developing an IRWM plan. The MWA IRWM plan crosses into the adjacent Colorado River Hydrologic Region, providing guidance on water management and water supply sustainability. The plan discusses objectives and management strategies related to stabilizing groundwater storage, protecting and restoring riparian habitat, and preventing groundwater quality degradation. MWA RWMG uses a combination of surface water, groundwater, and conservation to prevent long-term declines in groundwater storage, prevent land subsidence, and provide a sustainable water supply to meet current and future water demands.

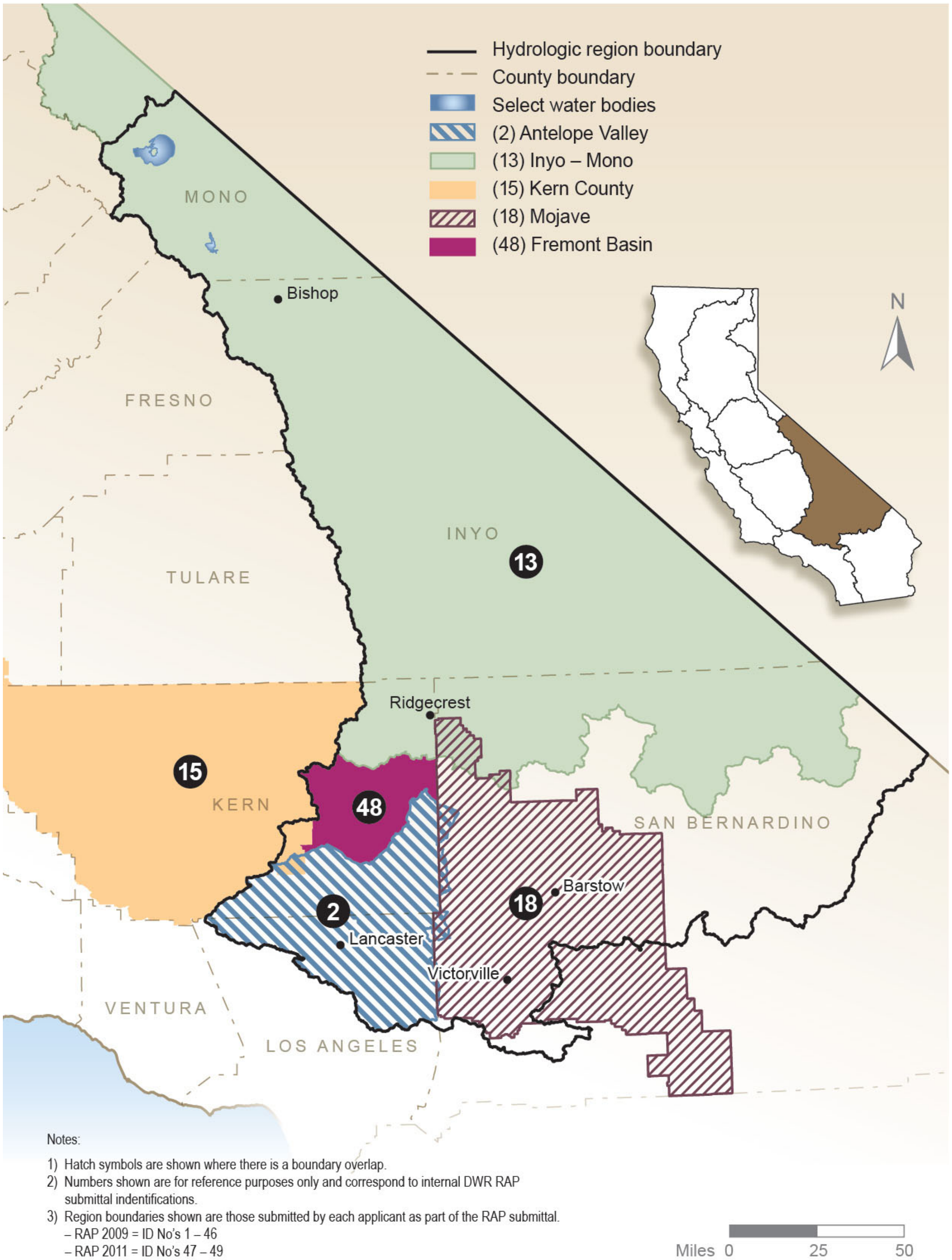
The Inyo-Mono IRWM plan is supported by more than two dozen entities in the region. The objectives of the RWMG are to ensure sustainable and reliable water supplies, improve water quality, efficient urban development, flood management, and ecosystem protection. The primary water issues in the region include threats to water quality caused by naturally occurring contaminants such as arsenic and uranium. A widespread concern in the region is a lack of proper infrastructure, which results in water loss and a lack of storage. The lack of efficient infrastructure severely limits the firefighting capabilities of many small communities. In addition to developing better infrastructure, the IRWM group is also interested in expanding water recycling programs and increasing the participation of small and disadvantaged communities.

The overall objective of the Antelope Valley RWMG is to provide water management plans to meet the expected demands for water and other resources within the region for the next few decades. A diverse group of public and private entities participated in the development and implementation of the IRWM plan. Strategies for achieving the long-term goal include conducting groundwater supply studies; initiating management actions; identifying financial resources to implement water management efforts; establishing cooperative stakeholder relationships; coordinating conjunctive use of surface water, imported water, and groundwater; educating the public regarding water conservation and awareness; and protecting groundwater quality.

The Kern IRWM planning area is primarily in the Tulare Lake Hydrologic Region, but it encompasses a small area in the southwestern portion of the South Lahontan region. The Kern IRWM plan was developed to provide guidance on water management and water supply sustainability within the agency's service area. The plan discusses objectives and management strategies related to stabilizing groundwater storage, protecting and restoring riparian habitat, and preventing groundwater quality degradation. The planning group uses a combination of surface water, groundwater, aquifer recharge, and water conservation to prevent long-term declines in groundwater storage, prevent land subsidence, and provide a sustainable water supply to meet current and future water demands.

Figure 11-14 shows the areas of the South Lahontan region covered by IRWM plans as of September, 2011. Table 11-22 lists the status of the IRWM planning areas by hydrologic region. More information about IRWM planning can be found at http://www.water.ca.gov/irwm/index.cfm.

Figure 11-14 Integrated Regional Water Management Plans in the South Lahontan Hydrologic Region



Notes:

1) Hatch symbols are shown where there is a boundary overlap.
2) Numbers shown are for reference purposes only and correspond to internal DWR RAP submittal indentifications.
3) Region boundaries shown are those submitted by each applicant as part of the RAP submittal.
   – RAP 2009 = ID No's 1 – 46
   – RAP 2011 = ID No's 47 – 49

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

Table 11-22 Status of Integrated Regional Water Management Plans in the South Lahontan Hydrologic Region

Hydrologic Region	IRWM Plan Name	Date	IRWM Plan Status	IRWM Map Number
South Lahontan	Antelope Valley	2007	Active	2
South Lahontan/ North Lahontan	Inyo – Mono	2011	Active	13
South Lahontan/ Tulare Lake	Kern	2009	Active	15
South Lahontan/ Colorado River	Mojave Water Agency Regional Water Management Plan	2004	Active	18
South Lahontan	Fremont Basin		In Progress	48

IRWM Planning Regions:	5
Active IRWM Plans:	4
IRWM Plans In Development:	1
IRWM Plans that Cross Hydrologic Boundaries:	3

Note:
IRWM = integrated regional water management
Table represents information as of August 2012.

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, and supplies, as well as 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, 2011to 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 being implemented include controlling drainage problems through alternative use of lands, using recycled water that otherwise would not be used beneficially, improving farm irrigation systems, and lining or piping ditches and canals. In addition, SB X7-7 requires that agricultural water suppliers:

- Report the status of AWMPs and efficient water management plans, and evaluate their effectiveness.
- Adopt regulations for measuring the volume of water delivered, and adopt 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.

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 use of surface water and groundwater has been utilized in the South Lahontan region for decades. To meet water demand, groundwater use is supplemented by surface water from local streams, rivers, or the SWP. Surface water is used to replenish aquifers. Many agencies have erected barrier systems to allow more efficient percolation of ephemeral runoff from surrounding mountains.

The largest surface-water storage and conveyance system in the region is the Los Angeles Aqueduct (LAA). The LAA is owned and operated by the Los Angeles Department of Water and Power. It consists of multiple dams, water diversions, and tunnels. The LAA is used primarily to transport water from tributaries to Mono Lake, and from the Owens River to Southern California. Southern California Edison also operates a series of dams and powerhouses on Mill Creek, Lee Vining Creek, Rush Creek, and Bishop Creek (Inyo-Mono Integrated Regional Water Management Program 2011). Water from the SWP is utilized in the Antelope Valley.

As part of *California Water Plan Update 2013*, an inventory and assessment of conjunctive management programs 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 the challenges, successes, and opportunities for growth. The results of the inventory would be shared 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 of associated benefits, costs, and issues, can be found in *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 from a coordinated DWR/ACWA survey.

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

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

Although initial response to the DWR/ACWA survey was encouraging, the number of survey participants and the completeness of those responses were limited. In an attempt to build on the survey and develop a greater understanding of the size and diversity of conjunctive management projects in California, staff from each of DWR's four region offices in the Division of Integrated Regional Water Management contacted, either by telephone or through e-mail, each of the entities identified as having a conjunctive management program. DWR's follow-up information gathering 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, 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. Conjunctive management and groundwater recharge programs in the planning and feasibility stage were not included in the inventory.

A statewide map and series of tables listing the conjunctive management projects identified by DWR and grouped by hydrologic region, with information specific to the 11 questions noted in this section, are provided in Appendix D. The project locations shown on the map represent the implementing agency's office address and do not represent the project location sites.

Conjunctive Management Inventory Results

Of the 89 agencies or programs identified as operating a conjunctive management or groundwater recharge program in California, two programs are located in the South Lahontan region. MWA and AVEK operate conjunctive use programs, but only MWA responded to the survey.

MWA operates a conjunctive management program which started in 1991 using direct groundwater percolation. The goals and objectives of the conjunctive management program are to address groundwater overdraft correction.

Annual recharge and extraction amounts vary year to year and are dependent upon other factors. Current recharge and extraction capacity is estimated at 50 taf per year, while the cumulative recharge capacity is estimated at 390 taf. Efforts are currently underway to increase program capacity. The SWP was identified as the source of program water. The current operating cost for the program is estimated at $900,000 per year.

MWA identified project cost as the most significant constraint for the program. Limited aquifer storage was determined to be a moderate constraint. Minimal constraints include political, legal, institutional, and water quality issues. Additional information describing conjunctive management practices in California, as well as discussion on associated benefits, costs, issues, and concerns, can be found in *California Water Plan Update 2013,* Volume 3, Chapter 9, "Conjunctive Management and Groundwater Storage."

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Edmund G. Brown Jr.
Governor
State of California

John Laird
Secretary for Natural Resources
Natural Resources Agency

Mark Cowin
Director
Department of Water Resources