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Acronyms and Abbreviations Used in This Report

[under development]

IWM	integrated water management
Update 2013	*California Water Plan Update 2013*

Sacramento River Hydrologic Region

Sacramento River Hydrologic Region Summary

The Sacramento River Hydrologic Region includes the entire California drainage area of the Sacramento River (the state's largest river) and its tributaries. The region extends from Chipps Island in Solano County north to Goose Lake in Modoc County. It is bounded by the Sierra Nevada on the east, the Coast Range on the west, the Cascade and Trinity Mountains on the north, and the Sacramento-San Joaquin Delta (Delta) on the south. The Sacramento River Basin actually begins in Oregon, north of Goose Lake, a near-sink that intercepts the Pit River drainage at the California-Oregon border.

Agriculture is the region's largest industry, contributing a wide variety of crops including rice, grain, tomatoes, field crops, fruits, and nuts. Agricultural acreages are detailed below in the watershed summaries.

In parts of the Sacramento River corridor, continuous tracts of vegetation have been converted to other vegetation types leading to scattered fragments of original habitat. Pre-dam factors that have also impacted the Sacramento fishery include railroad construction upstream of Shasta Dam, drainage from Iron Mountain Mine, and historic gold mining in the Feather and Yuba basins. In the lower Feather River, hydraulic mining impacted its channel and floodplain with up to 20 feet of sediment (Anderson 2012). In the Yuba River, mining debris completely covered salmon spawning beds and floodplain for up to one and one-half miles from the river with sediments five to ten feet in thickness (Yoshiyama et al. 1998 as referenced by Vogel 2011).

Water development projects have also altered natural geomorphic river processes resulting in reduced spawning habitat and fragmented riparian systems. Spring-run salmon cannot access most of their historic spawning and rearing habitats above the dams and spawning is now restricted to the mainstem of the Sacramento River and a few tributaries. On the positive side, the dams provide increased flexibility with cold water releases and increased flows during summer months providing conditions more favorable to salmon (Vogel 2011).

In recent years, salmon populations have been a concern to the extent that the Pacific Fisheries Marine Council and the National Marine Fisheries Service (NMFS) closed commercial and most recreational fishing in 2007, 2008, and 2009. At issue in the Central Valley is the potential loss of the genetic diversity that Central Valley Chinook populations lend to the species. This region has the southern-most spawning populations which are at a greater risk of extinction than most coastal populations. Central Valley populations may lend the genetic diversity necessary for the species survival and are therefore considered a high priority for conservation (Zueg et. al. 2011).

In light of these issues, habitat conditions for anadromous fish have significantly improved over that last two decades. Adult fish passage has improved with the removal of major fish barriers, water temperatures have improved downstream of the major dams, discharges from Iron Mountain Mine have been remediated, and major efforts have been undertaken to screen unscreened or inadequately screened water diversions (Vogel 2011). These efforts continue under several federal and State programs focused on species and ecosystem components considered to be at high risk.

PLACEHOLDER Figure SR-1 Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Current State of the Region

Setting

Watersheds

The following provides a short description and summary of issues for watersheds (see Figure SR-2) identified by the NMFS as having core populations of salmon and steelhead. These watersheds have the physical and hydrologic features considered necessary for the recovery of these species.

PLACEHOLDER Figure SR-2 Sacramento River Hydrologic Region Watersheds

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Clear Creek Watershed

Clear Creek originates in the mountains east of Clair Engle Reservoir and drains an area of approximately 238 square miles (NMFS 2009). Whiskeytown Dam stores and regulates run-off from the Clear Creek watershed. Flows provided to Clear Creek below Whiskeytown Dam are at least 200 cfs from October through June. During the summer months, flows are maintained to provide adequate water temperatures for holding adult spring-run Chinook salmon and for rearing steelhead (NMFS 2009). Construction of Whiskeytown Dam and gold and gravel mining has reduced suitable spawning gravels and riparian habitat along the lower sections of Clear Creek (NMFS 2009).

Clear Creek is designated critical habitat for spring-run and CV steelhead. Key threats and stressors for creek include:

- Passage barrier at Whiskeytown Dam
- Water temperature and quality
- Habitat alteration and availability of instream gravel
- Flow conditions
- Sedimentation
- Loss of floodplain habitat and natural river morphology

The Clear Creek Floodway Rehabilitation Project, which began in 1998, has been responsible for helping to redefine the creek channel and floodplain, isolate salmon from stranding, and has provided for riparian habitat. The general purpose of the project is to restore steam channels; determine long-term flow needs for spawning, incubation, and rearing; provide flows to meet the requirements of all life stages of Chinook salmon and steelhead trout; provide spawning gravel to replace supplies blocked by Whiskeytown Dam; and monitor the results.

Spawning habitat on Clear Creek is improving with restoration efforts, gravel augmentation, and increased flows for temperature control. Recent studies on Clear Creek using a gravel size suitable for steelhead have found that steelhead have utilized all newly added injection sites (NMFS 2009b). By the year 2020, the overall goal for spawning gravel supplementation is to provide 347,228 square feet of usable spawning habitat between Whiskeytown Dam and the former McCormick-Saeltzer Dam. The annual spawning gravel supplementation target is 25,000 tons per year but an average of 9,358 tons have been placed annually since 1996 due to funding constraints (USBR 2011d).

CVPIA has provided funding for the design and permitting of projects on BLM and DFG lands to provide a long-term supply of spawning gravel. The projects reduces the threat of mercury contamination through separation and relocation of contaminated materials, and provide an economical 40-year supply of gravel while using renovated mine tailings to restore floodplain and upland habitats (USBR 2011d). The value of potential spawning habitat may be reduced under future operations in critically dry years when cold water releases cannot be maintained from Whiskeytown Dam (i.e., years when Trinity River diversions are reduced).

Under CVPIA 3406(b)(2), interim flows have been increased to 200 cfs from 50 cfs for the period of September through mid-June and to approximately 70 to 90 cfs during the summer for temperature control. The flow of 200 cfs was based on flow studies conducted in the mid 1980's. FWS has conducted new flow studies for both the lower and upper segments of the creek which are due to be completed in 2011 and 2012. Studies have also been conducted to develop channel maintenance flows to reactivate fluvial geomorphic processes. FWS has set a minimum target pulse flow release of 3,250 cfs from Whiskeytown Dam for one day occurring 3 times during a ten year period between the dates of March 1 and May 15. Results of pulse flows in 2010 suggested that higher flows are needed (USBR 2011b). Other flow actions include pulse flows in May and June to attract spring-run to the higher reaches where cooler water temperatures can be maintained over the summer holding period (NMFS 2009b).

Cottonwood Creek Watershed

The Cottonwood Creek watershed is the largest tributary to the Sacramento River on the west side of the valley and is an important source of spawning gravel to the upper Sacramento River (CDFG 2011). It's estimated that the creek supplies almost 85 percent of the coarse sediments and spawning gravel for the Sacramento River between Redding and Red Bluff. As such this creek plays an important role in the recovery of listed species. Changes in the creek since the early 1970's have occurred such as rapid shifts in stream channel alignment, increased bank erosion, and damage to adjacent properties in the lower 15 miles of the creek. The changes appear to be the result of aggregate extraction in excess of annual replenishment rates (Matthews 2003).

Cottonwood Creek itself does not have suitable habitat to support a spring-run Chinook salmon population (NMFS 2009). Viability potential for spring-run Chinook salmon is considered low. Viability for steelhead is considered moderate (NMFS 2009).

Cow Creek Watershed

The Cow Creek watershed is located in eastern Shasta County and encompasses about 430 square miles. The watershed consists of five main tributaries: Little Cow Creek, Oak Run Creek, Clover Creek, Old Cow Creek, and South Cow Creek.

Irrigation in the watershed consists of a series of diversions and lift-pumps in all tributaries. Water rights in the Cow Creek watershed are adjudicated and there are approximately 278 recorded diversions. The primary water quality issues in the watershed are related to bacteria, temperature, and erosion/sediment discharge. North Fork Cow, Clover, Oak Run, and South Fork Cow Creeks are all 303(d) listed as impaired waterbodies for bacteria. The watershed provides habitat for fall-run and late fall-run Chinook salmon and steelhead.

The watershed has low viability potential to support spring-run Chinook salmon and moderate viability potential to support a population of steelhead (NMFS 2009). Sections of the watershed do not have suitable habitat and insufficient flows result in warmer water temperatures. Extensive restoration is needed for a population to spring-run Chinook to persist (NMFS 2009). Key stressors to steelhead include passage impediments/barriers, flow conditions, water temperatures, predation, hatchery effects and entrainment at unscreened diversions.

Antelope Creek Watershed

Antelope Creek is considered critical habitat for spring-run Chinook salmon and steelhead. According to the draft NMFS Recovery Plan, Antelope Creek has high potential to support a viable population of steelhead. The creek is characterized as having a moderate potential to support a viable population of spring-run Chinook. The upper reaches of the creek are fairly undeveloped. Issues in the watershed concern impaired stream flows and fish passage on the valley floor below agricultural diversion. The primary focus for restoration is on improving flow conditions and fish passage for upstream migrating adults.

Battle Creek Watershed

The Battle Creek watershed includes the southern slopes of the Latour Buttes, the western slope of Mt. Lassen, and mountains south of the town of Mineral. The watershed drains an area of approximately 360 square miles.

Battle Creek may be the only remaining tributary to the Sacramento River that can sustain breeding populations of steelhead and all four runs of Chinook salmon. The watershed has been identified as having high potential for the recovery of spring-run Chinook salmon due to its relatively high and consistent cold water flow. Battle Creek also has the largest base flow season of any of the tributaries to the Sacramento River between Keswick Dam and the Feather River.

Current restoration actions include the installation of fish ladders and fish screens at three dams. Construction is expected to be completed in 2014. Other restoration actions include the removal of small dams on the South Fork Battle Creek, increasing flows from existing diversions, and hatchery releases. Once restoration actions are completed, 42 miles of additional habitat will be reestablished plus an additional 6 miles of habitat within area tributaries.

Big Chico Creek Watershed

Big Chico Creek begins in Chico Meadows and flows approximately 45 miles to its confluence with the Sacramento River. The creek can be divided into three zones: the upper zone extending from the headwaters to Higgin’s Hole, a middle zone extending from Higgin’s Hole to Iron Canyon, and the third zone extending from Iron Canyon to the Sacramento River (NMFS 2009).

Mud Creek and Rock Creek join Big Chico Creek about 0.75 miles before it enters the Sacramento River. These creeks provide seasonal flows from about November to June in the valley portions of their channels. An outflow weir at Lindo Channel diverts excess flows from Big Chico Creek through a diversion channel to Sycamore Creek which then flows into Mud Creek (NMFS 2009).

The lowermost 24 miles of Big Chico Creek provide aquatic habitat for anadromous salmonids. The creek provides habitat for adult spring-run Chinook salmon holding and spawning, while Mud, Rock and Sycamore creeks have been shown to be important non-natal rearing areas for salmonids (NMFS 2009).

Bear River Watershed

The Bear River originates on the west side of the Sierra Nevada and flows to the southwest about 65 miles to its confluence with the Feather River. The upstream limit for anadromous fish is the South Sutter Irrigation District's diversion dam. The river contains a large volume of mining sediment stored in its main channel - estimated to be up to 160 million cubic yards (NMFS 2009).

The potential for Bear River to support a viable population of steelhead is considered low. This is due to a limited amount of habitat for spawning and rearing at suitable elevations. Inadequate stream flow prevents the establishment of a self-sustaining steelhead population (NMFS 2009).

Butte Creek Watershed

The Butte Creek watershed originates on the western slope of the Sierra Nevada Mountains and encompasses about 800 square miles. The watershed contains a series of dams, diversions, and canals that are mostly located in the middle and lower canyon portions of Butte Creek. The hydrology of Butte Creek has been extensively modified and developed, contains multiple hydropower diversions, and imports water from other watersheds. Land use within the watershed includes agricultural uses (64%) with rice production being the most dominant crop, forest related uses (13%) with the remaining lands used for commercial, industrial, and residential uses (NMFS 2009).

Restoration actions have included the removal of Western Canal, McPherrin, McGowan, and Point Four Dams, screening modifications or construction on five other diversions, and construction of a canal siphon along Butte Creek to aid fish passage (CDFG 2011).

Butte Creek is considered to have moderate potential to support a viable population of steelhead. Key stressors to spring-run Chinook salmon and steelhead include water temperatures, passage impediments/barriers, flow fluctuations, summer instream recreation, upper watershed conditions and fire risk. Watershed management objectives and recommended actions to achieve the objectives are included in the Butte Creek Watershed Management Strategy (2000).

Mill Creek Watershed

The Mill Creek watershed originates on the southern slopes of Lassen Peak and encompasses about 134 square miles. Mill Creek initially flows though meadows and dense forests before descending through a steep rock canyon to the Sacramento Valley. There are three dams on Mill Creek. Two are operated by the Los Molinos Mutual Water Company and one is operated by the Clough and Owens ranches.

During low flow periods, existing water rights are sufficient to dewater the stream. There are cooperative agreements between resource agencies and water diverters to provide adequate flows for salmon during peak migration/spawning periods. An interagency water exchange agreement is in place which provides pumped groundwater to meet irrigation water needs during critical time periods (sacriver.org).

Mill Creek supports the majority of its original native aquatic species assemblages (NMFS 2009). The main focus for spring-run Chinook salmon restoration is to maintain flow conditions for upstream migrating adults. Mill Creek is considered to have high potential to support a viable independent population with few restoration actions. Threats and stressors identified for spring-run Chinook salmon and steelhead include elevated water temperatures, low stream flows, and risk of catastrophic fire. Concerns about water temperatures apply mainly to the lower reaches of the creek.

Deer Creek Watershed

The watershed originates near the summit of Butt Mountain and drains an area of about 134 square miles. Deer Creek initially flows through meadows and dense forest and then descends through a steep canyon to the Sacramento Valley. Highway 32 runs parallel to Deer Creek in the upper watershed which is a major concern with respect to the possibility of a spill event (sacriver.org).

Deer Creek contains about 40 miles of anadromous fish habitat with approximately 25 miles of adult spawning and holding habitat. The three diversion dams (the Cone-Kimball Diversion, Stanford-Vina Dam, and Deer Creek Irrigation District Dam) present passage impediments to adult steelhead during low flow periods. Water temperatures throughout the watershed are suitable for juvenile steelhead rearing except for summer months when temperatures in the lower watershed are too high (NMFS 2009). The viability potential for spring-run Chinook salmon and steelhead is considered high (NMFS 2009).

Feather River Watershed

The Feather River watershed is part of the northern Sierra Nevada mountain range and is the source of water for Lake Oroville. The USFS manages over 80 percent of the Feather River upper watershed.

The watershed has two general terrains. Divided by the Sierra Crest, the west side of the watershed is made up of steep forested valleys and the east side consists of less steep terrain and broad valley floors. Because of the steep terrain, west side surface streams are less susceptible to degradation from erosion and head cutting. The east side of the watershed is more degraded by the loss of riparian and upland vegetation, deep channel incision, and sediment runoff from forest logging roads.

Meadows are the most sensitive landforms in the watershed. Meadows are remnant lake bottoms with highly erodible soil types that can produce great volumes of sediments. Meadow restoration has been a major component of the restoration efforts in the region. Meadow restoration has reduced erosion, increased aquifer storage, and improved riparian vegetation.

Each of the main stems and tributaries of the Upper Feather River have some degree of degradation. Fish habitat and passage have been impacted by stream channelization to control flooding, sediment deposition resulting from bank erosion and runoff, and loss of riparian vegetation. The goals of the Upper Feather River Integrated Regional Water Management Plan support the rehabilitation of all streams to "functional, ecologically healthy conditions that support aquatic biota" (ESF 2005).

Hydropower in the region includes projects on the North Fork Feather River and Lake Oroville. The Rock Creek-Cresta Project (FERC License 1962) operated by PG&E is located on the North Fork Feather River in Plumas and Butte Counties. In 1991, PG&E and CDFG entered into a Fish and Wildlife Agreement to establish minimum streamflows and other resource management measures for the protection, mitigation, and enhancement of fish and wildlife resources (ESF 2005).

The North Fork Feather River Project 2105 (FERC License 2105) is located in Plumas County. PG&E filed a settlement agreement with the FERC in 2004 as part of relicensing. Under the agreement, PG&E will operate Lake Almanor to specified lake levels and required releases below Canyon Dam. Fish flows in the Belden Reach and Seneca Reach will be increased depending on the month and water year type. PG&E will also release pulse flows in both reaches in certain months during wet or normal years.

There are two reaches of the Feather River where both fall-run and spring-run Chinook spawn: the low-flow channel from Oroville to Thermalito Afterbay outlet, and the lower reach from Thermalito Afterbay outlet to Honcut Creek (Vogel 2011). Approximately 75 percent of the natural fall-run spawn in the eight-mile reach between the Fish Barrier Dam and the Thermalito Afterbay outlet (Vogel 2011). Gravel recruitment is an issue for the low-flow channel of the river. Water temperatures range from 47 F in the winter to 65 F in the summer (Vogel 2011). The summer water temperatures can limit salmon production.

Recovery and restoration actions identified for the Feather River include the development of a hatchery genetic management plan for the Feather River Fish Hatchery, development and implementation of a spring-run pulse flow schedule that is coordinated with Yuba River operations, gravel augmentation, and implement facility modifications to meet water temperature goals (NMFS 2009).

American River Watershed

The American River watershed is part of the Sierra Nevada Mountain range and drains an area of approximately 1,895 square miles (Lee DP and Chilton J 2007). The river accounts for about 15 percent of the Sacramento River flow. The medium historical unimpaired run-off is 2.5 maf, ranging from 0.3 to 6.4 maf.

Folsom Dam is located on the river and impounds the south and north forks of the American River. The dam is part of the CVP. Nimbus Dam and Powerplant are located 6.8 miles downstream of Folsom Dam. Nimbus Dam re-regulates water released from Folsom Dam and diverts water to the Folsom South Canal. Water not diverted to the canal is released to the American River. Both dams are a factor with respect to the restoration potential of the river. Bank erosion, channel degradation, riprap revetments, and reduced amounts of woody debris have all contributed to the decline of riparian vegetation.

The Nimbus Fish Hatchery is located adjacent to the American River approximately 15 miles east of the City of Sacramento. The goal of the hatchery is to mitigate for spawning habitat eliminated by the construction of the Nimbus Dam. Chinook salmon reared at the hatchery are considered part of the Central Valley fall-run.

The river currently provides about 23 miles of riverine habitat to anadromous salmonids. Warm water temperatures in the lower American River during the summer and fall are considered to be the primary stressor to steelhead. Above Folsom Lake, riverine habitat is available in the North, Middle, and South forks of the river; however, the quality of habitat needs to be assessed (NMFS 2009).

The potential for the lower American River to support a viable population of steelhead is considered low. The natural population is considered to be at high risk of extinction because most of the fish population is from the hatchery. The potential for a viable population above the dams is considered moderate for spring-run salmon and steelhead. The reintroduction of spring-run Chinook salmon to the North and Middle forks of the river would represent separate fish populations.

Yuba River Watershed

Yuba River is a tributary of the Feather River and provides about a third of the Feather River flow. The main stem of the river is about 40 miles long and is split between the North, Middle, and South forks. The confluence of the North and Middle forks is considered the beginning of the Yuba River. The North Yuba River extends for about 61 miles and is impounded by New Bullards Reservoir after which in joins the Middle Yuba. New Bullards Bar Dam and Reservoir provides favorable conditions for over-summering spring-run Chinook in the lower Yuba River due to higher colder flows (Vogel 2011).

The Yuba River then flows southwest to Englebright Lake where it is joined by South Yuba. Construction of the Englebright Dam was completed in 1941 to hold back hydraulic mining debris from historic placer mining. The dam is located approximately 24 miles upstream of the Feather River. Prior to construction of dam, steelhead had been observed spawning in the uppermost reaches of the river.

Below Englebright Dam, the river is characterized as having high potential to support a viable population of steelhead. Daguerre Point Dam is located approximately 11.5 miles upstream of the Feather River. The dam was reconstructed in 1965; however, the fish ladders are considered suboptimal.

Flow, water temperature, and habitat conditions are generally suitable to support all life stage requirements. Proposed restoration actions include gravel augmentation below Englebright Dam and improvement of rearing habitat by increasing floodplain habitat availability. Above Englebright Dam, recovery actions include increasing minimum flows; providing passage at Our House, New Bullards Bar, and Log Cabin dams; and assessing the feasibility of passage improvement at natural barriers (NMFS 2009).

Groundwater Aquifers

Groundwater resources in the Sacramento River Hydrologic Region are supplied by both alluvial and fractured rock aquifers. Alluvial aquifers are composed of sand and gravel or finer grained sediments, with groundwater stored within the voids, or pore space, between the alluvial sediments. Fractured-rock aquifers consist of impermeable granitic, metamorphic, volcanic, and hard sedimentary rocks, with groundwater being stored within cracks, fractures, or other void spaces. The distribution and extent of alluvial and fractured-rock aquifers and water wells vary within the region. A brief description of the aquifers for the region is provided below.

Aquifer Description

Alluvial Aquifers

The Sacramento River Hydrologic Region contains 88 DWR Bulletin 118-2003 recognized alluvial groundwater basins and subbasins which underlie approximately 7,800 square miles, or 29 percent of the region. Most of the groundwater in the region is stored in alluvial aquifers. Figure SR-3 shows the location of the alluvial groundwater basins and subbasins and Table SR-1 lists the associated names and numbers. Pumping from the alluvial aquifers in the region accounts for about 17 percent of California's total average annual groundwater extraction. The largest and most heavily used groundwater basins in the Sacramento River Hydrologic Region are located primarily within the Sacramento Valley Groundwater Basin. Within the Sacramento Valley Groundwater Basin, the Colusa, East Butte, North American, Solano, and Yolo Subbasins account for more than 50 percent of the groundwater used in the region. Other significant groundwater basins in the region are Redding Area, Alturas Area, Big Valley, and Fall River Valley Groundwater Basins.

PLACEHOLDER Figure SR-3 Alluvial Groundwater Basins and Subbasins within the Sacramento River Hydrologic Region

PLACEHOLDER Table SR-1 Alluvial Groundwater Basins and Subbasins within the Sacramento River Hydrologic Region

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The Sacramento Valley Groundwater Basin is underlain by an extensive alluvial aquifer system covering approximately 3.8 million acres. Well yield data (from well completion reports) indicates that the average groundwater production varies greatly among the subbasins within the basin, ranging between 275 and 2,000 gpm. The primary fresh groundwater-bearing formations in the Sacramento Valley Groundwater Basin are the Tehama, Tuscan, Laguna, and Mehrten Formations. The Tehama Formation is derived from material eroded from the Coast Ranges and Klamath Mountains. The Tehama Formation is present in both surface exposures and in the subsurface of the valley where it is overlain by more recent alluvial material. In the valley, the Tehama Formation consists of interbedded gravel, sand, silt, and clay layers. Gravel and sand layers within the Tehama Formation can yield moderate to high amounts of water in many locations. The Tuscan Formation is derived primarily from mud flow and reworked volcanic deposits originating near Lassen Peak. In the valley, the Tuscan Formation consists of interbedded layers of gravel, sand, silt, and clay. Gravel and sand layers within the Tuscan Formation can yield moderate to high amounts of groundwater in many locations. The Laguna Formation is composed of material eroded from the Sierra Nevada. Similar to the Tehama Formation, the Laguna Formation is exposed at the surface along the rolling hills near the eastern edges of the valley. The Laguna Formation consists of layers of gravel, sand, and silt. Gravel and sand layers within the Laguna Formation are more limited than in the Tehama and Tuscan formations, and can yield moderate amounts of water. The Mehrten Formation is composed of volcanic material eroded from an ancient version of the Sierra Nevada. It consists of two distinct units, a dark-gray andesitic sand and gravel, and an andesitic tuff-breccia. Thickness of the Mehrten Formation can be greater than 1,000 feet in many locations within the valley. The andesitic sand and gravel unit is highly permeable and can yield large amounts of groundwater in many locations. In localized areas, the recent alluvium can be a significant source of groundwater for domestic, agricultural, and public use, but generally these units provide a modest amount of water to primarily domestic users.

The Redding Area Groundwater Basin covers approximately 390,000 acres. The groundwater basin is divided into six subbasins - Bowman, Rosewood, Anderson, Enterprise, Millville, and South Battle Creek. These subbasins overlay portions of both Shasta and Tehama Counties. The center of the groundwater basin is underlain by a fairly thick alluvial aquifer system, which thins towards the edges of the basin, and along smaller valleys adjacent to local stream and river channels. Similar to the Sacramento Valley Groundwater Basin, the primary fresh groundwater-bearing formations in the Redding Area Groundwater Basin include the Tuscan and Tehama formations. Well yield data indicate that groundwater production in the groundwater basin varies between 10 and 2,000 gpm, with an average yield of about 300 gpm.

Northeast of the Sacramento Valley Groundwater Basin, 28 basins and subbasins are located in Modoc, Siskiyou, Lassen, and Shasta counties. The major groundwater basins within this area are the Alturas Area, Big Valley, and Fall River Valley Basins.

The Alturas Area Groundwater Basin includes the South Fork Pit River and the Warm Springs Valley Subbasins. The two subbasins cover approximately 182,000 acres in Lassen and Modoc counties. The principle water-bearing formation in the two subbasins is the Alturas Formation consisting of beds of volcanic ash (tuff), ashy sandstone, and diatomite. The formation can be as thick as 800 feet in some locations. With a moderate to high permeability and significant thickness, this formation can yield large amounts of groundwater to wells in many locations. Well yield data indicate that production is significantly higher in the South Fork Pit River Subbasin with estimated well yields between 50 and 5,000 gpm, with an average yield of 1,000 gpm. Well yield data for the Warm Springs Valley Subbasin indicate estimated yields between 100 and 400 gpm, with an average yield of 300 gpm.

The Big Valley Groundwater Basin covers 92,000 acres in Lassen and Modoc counties. The principle water-bearing formation is the Bieber Formation consisting of clay, silt, sand, and gravel interbedded by its deposition in a lake environment. This formation is up to 2,000 feet thick in some locations. With a moderate permeability and significant thickness, this formation can yield large amounts of water in many locations. Estimated well yields range between 100 and 4,000 gpm, with an average of 900 gpm.

The Fall River Valley Basin covers 54,800 acres in Lassen and Shasta counties. The principle alluvial water-bearing formations in the groundwater basin are the Pleistocene lake and near-shore deposits and Holocene sedimentary deposits. The near-shore deposits consist of clay, silt, and sand, and have a maximum depth of 300 feet. This formation can yield moderate amounts of groundwater in some locations. Holocene sedimentary deposits consist of silt, sand, and gravel. This formation can yield moderate amounts of groundwater in areas where it is both sufficiently permeable and thick. However, in most areas, the formation is significantly less than 100 feet thick. Estimated well yields can go up to 1,500 gpm, with an average of 270 gpm.

Fractured-Rock Aquifers

Fractured-rock aquifers are generally found in the mountainous areas of a hydrologic region, extending from the edges of the alluvial groundwater basins and foothill areas, up into the surrounding mountains. Due to the highly variable nature of void spaces within fractured-rock aquifers, wells drawing from fractured-rock aquifers tend to have less capacity and less reliability than wells drawing from alluvial aquifers. On average, wells drawing from fractured-rock aquifers yield 10 gpm or less. Although the volume and rate of groundwater supplied by fractured-rock aquifers is small in comparison to groundwater resources supplied by alluvial aquifers, fractured-rock aquifers tend to be a critically important water supply source for many individual domestic wells and small public water systems within the Sacramento River Hydrologic Region.

The principle fractured-rock aquifers in the Fall River Valley Groundwater Basin are Pliocene to Holocene Volcanic rocks consisting of highly fractured basalt flows interbedded with layers of cinders. The basalt flows are the only component of the formation with a broad enough extent to be a significant source of groundwater. Where the basalt is fractured and open, well yields can be high; but where the basalt is impermeable, little to no groundwater can be produced.

More detailed information regarding the aquifers in the Sacramento River Hydrologic Region is available online from California Water Plan Update 2013 (Update 2013), Volume 4, Reference Guide, the article "California's Groundwater Update 2013" and DWR Bulletin 118-2003.

Well Infrastructure and Distribution

Well logs submitted to DWR for water supply wells completed during 1977 through 2010 were used to evaluate the distribution of water wells and the uses of groundwater in the Sacramento River Hydrologic Region. DWR does not have well logs for all the wells drilled in the region; and for some well logs, information regarding well location or use is inaccurate, incomplete, ambiguous, or missing. Hence, some well logs could not be used in the current assessment. However, for a regional scale evaluation of well installation and distribution, the quality of the data is considered adequate and informative. The number and distribution of wells in the region are grouped according to their location by county and according to six most common well-use types - domestic, irrigation, public supply, industrial, monitoring, and other. Public supply wells include all wells identified in the well completion report as municipal or public. Wells identified as "other" include a combination of the less common well types, such as stock wells, test wells, or unidentified wells (no information listed on the well log).

The number and type of wells listed by county are not necessarily indicative of number and type of wells within the entire hydrologic region. Well log data for counties that fall within multiple hydrologic regions are assigned to the hydrologic region containing the majority of alluvial groundwater basins within the county. Of the 22 counties located completely or partially within the Sacramento River Hydrologic Region, seventeen counties were included in the analysis of well infrastructure for the region. Nine of these seventeen counties are fully contained with the region, while eight counties are partially contained within the region. Well log information listed in Table SR-2 and illustrated in Figure SR-4 show that the distribution and number of wells vary widely by county and by use. The total number of wells installed in the region between 1977 and 2010 is approximately 108,000, and ranges from a high of about 14,000 in Nevada County to under 400 in Sierra County.

The top five counties for domestic wells include Nevada, Placer, El Dorado, Butte, and Tehama, with a range between approximately13,000 and 8,000. Sacramento, Solano, Shasta, Butte, and Yolo Counties have the highest number of monitoring wells with a range between approximately 6,900 and 1,000. Regions having a high percentage of monitoring wells, compared to other well types, tend to also have a higher number of local groundwater quality problem areas. Counties with the most irrigation wells include Butte, Glen, Yolo, Sutter, and Tehama, with a range between approximately 1,200 and 600.

PLACEHOLDER Table SR-2 Number of Well Logs by County and Use for the Sacramento River Hydrologic Region (1977-2010)

PLACEHOLDER Figure SR-4 Number of Well Logs by County and Use for the Sacramento River Hydrologic Region (1977-2010)

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Figure SR-5 shows that domestic wells make up the majority of well logs (72 percent) for the region, followed by monitoring wells (15 percent), and irrigation wells (about 6 percent). Statewide, domestic and irrigation wells account for about 54 and 10 percent per hydrologic region based on the total number of wells in the state.

PLACEHOLDER Figure SR-5 Percentage of Well Logs by Use for the Sacramento River Hydrologic Region (1977-2010)

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Figure SR-6 shows a cyclic pattern of well installation for the region, with new well construction ranging from about 1,500 in 2010 to 5,300 in 1990, with an average of about 3,200 wells per year. Installation trends for irrigation wells tend to closely follow changes in hydrology, cropping trends, and availability of alternate agricultural water supplies. Irrigation well installation in the region peaked at around 800 wells per year following the 1976-1977 drought, and continued at an average installation rate of 400 wells per year through 1981. Irrigation well installation dropped to under 100 wells per year during the wet years of the mid-1980s, before increasing to an average of about 400 wells per year during the 1989-1994 drought and about 250 wells per year during the 2008-2009 drought. Much of the irrigation well infrastructure installed in the region during the late 1970's and early 1980s is still in use today.

The large fluctuation of domestic well drilling is likely associated with population booms and residential housing construction. The increase in domestic well drilling in the region during the late 1980s and early 1990s as well as early through mid-2000s is likely due to increases in housing construction during this time. Similarly, the 2007 to 2010 decline in domestic well drilling is likely due to declining economic conditions and related drop in housing construction. A portion of the lower number of well logs recorded for 2010 could also be due to delays in receiving and processing well drillers logs.

PLACEHOLDER Figure SR-6 Number of Well Logs Filed per Year by Use for the Sacramento River Hydrologic Region (1977-2010)

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Monitoring wells in the region were first recorded in significant numbers in 1982, with over 140 wells installed; the number increased to a high of about 900 in 1992. 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. Between 1984 and 2010, monitoring well installation in the region has averaged approximately 600 wells per year.

More detailed information regarding assumptions and methods of reporting well log information is available online from Update 2013, Volume 4, Reference Guide, the article "California's Groundwater Update 2013."

California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization

The Legislature in 2009, as part of a larger package of water-related bills, passed Senate Bill 7x 6 (SBx7 6; Part 2.11 to Division 6 of the California Water Code § 10920 et seq.), requiring that groundwater elevation data be collected in a systematic manner on a statewide basis and be made readily and widely available to the public. DWR was charged with administering the program, which was later named the "California Statewide Groundwater Elevation Monitoring" or "CASGEM" Program. The new legislation requires DWR to identify the current extent of groundwater elevation monitoring within each of the alluvial groundwater basins defined under Bulletin 118-2003. The legislation also requires DWR to prioritize groundwater basins to help identify, evaluate, and determine the need for additional groundwater level monitoring by considering available data. Box SR-1 provides a summary of these data considerations and resulting possible prioritization category of basins.

More detailed information on groundwater basin prioritization is available online from Update 2013, Volume 4, Reference Guide, the article "California's Groundwater Update 2013."

PLACEHOLDER Box SR-1 California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization Data Considerations

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Figure SR-7 shows the groundwater basin prioritization for the region. Of the 88 basins within the region, five subbasins in the Sacramento Valley Groundwater Basin were identified as high priority, 16 basins and subbasins as medium priority, seven basins as low priority, and the remaining 60 basins and subbasins as very low priority. Table SR-3 lists the high and medium CASGEM priority groundwater basins for the region. The 21 high and medium priority basins and subbasins account for 97 percent of the population and 89 percent of groundwater supply in the region. The basin prioritization could be a valuable tool to help evaluate, focus, and align limited resources for effective groundwater management, and reliability and sustainability of groundwater resources.

PLACEHOLDER Figure SR-7 CASGEM Groundwater Basin Prioritization for the Sacramento River Hydrologic Region

PLACEHOLDER Table SR-3 CASGEM Groundwater Basin Prioritization for the Sacramento River Hydrologic Region

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Sacramento River Hydrologic Region 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 (§10753.7) requires local agencies seeking State funds administered by DWR to prepare and implement groundwater management plans 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. This section summarizes some of the groundwater level, groundwater quality, and land subsidence monitoring efforts within the Sacramento River Hydrologic Region. Groundwater level monitoring well information includes only active monitoring wells — those wells that have been measured since January 1, 2010.

Additional information regarding the methods, assumptions, and data availability associated with the groundwater monitoring is available online from Update 2013, Volume 4, Reference Guide, the article "California's Groundwater Update 2013."

Groundwater Level Monitoring

A list of the number of monitoring wells in the region by monitoring agencies, cooperators, and CASGEM monitoring entities is provided in Table SR-4. The locations of these monitoring wells by monitoring entity and monitoring well type are shown in Figure SR-8.

Table SR-4 shows that a total of 1,306 wells in the region have been actively monitored for groundwater levels since 2010. DWR monitors a total of 635 wells in 36 basins and subbasins; the USBR monitors 150 wells in six basins and subbasins; and the USGS monitors groundwater levels in four wells in two subbains. In addition to the State and federal agency, six cooperators and 14 CASGEM monitoring entities combined monitor a total of 517 wells in 19 basins and subbasins. A comparison of Figure SR-7 discussed previously and Figure SR-8 indicate that all basins identified as having a high or medium priority under the CASGEM groundwater basin prioritization have been monitored for groundwater levels.

PLACEHOLDER Table SR-4 Groundwater Level Monitoring Wells by Monitoring Entity in the Sacramento River Hydrologic Region

PLACEHOLDER Figure SR-8 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity in the Sacramento River Hydrologic Region

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The groundwater level monitoring wells are categorized by the type of well use and include domestic, irrigation, 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. Domestic wells are typically relatively shallow and are in the upper portion of the aquifer system, while irrigation wells tend to be deeper and are in the middle-to-deeper portion of the aquifer system. Some observation wells are constructed as a nested or clustered set of dedicated monitoring wells, designed to characterize groundwater conditions at specific and discrete production intervals throughout the aquifer system. Figure SR-9 shows that wells identified as irrigation, observation, and domestic account for 36, 32, and 21 percent, respectively, of the monitoring wells in the region, while wells listed as other comprise 11 percent of the total.

PLACEHOLDER Figure SR-9 Percentage of Monitoring Wells by Use in the Sacramento River Hydrologic Region

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Groundwater Quality Monitoring

Groundwater quality monitoring is an important aspect to effective groundwater basin management and is one of the components that are required to be included in groundwater management planning in order for local agencies to be eligible for State funds. Numerous State, federal, and local agencies participate in groundwater quality monitoring efforts throughout California. A number of the existing groundwater quality monitoring efforts were initiated as part of the Groundwater Quality Monitoring Act of 2001, which implemented goals to improve and increase the statewide availability of groundwater quality data.

A summary of the larger groundwater quality monitoring efforts and references for additional information are provided below.

Regional and statewide groundwater quality monitoring information and data are available on the SWRCB Groundwater Ambient Monitoring and Assessment (GAMA) Web site and the GeoTracker GAMA groundwater information system developed as part of the Groundwater Quality Monitoring Act of 2001. The GAMA Web site describes GAMA program and provides links to all published GAMA and related reports. The GeoTracker GAMA groundwater information system geographically displays information and includes analytical tools and reporting features to assess groundwater quality. This system currently includes groundwater data from the SWRCB, Regional Water Quality Control Boards (RWQCBs), California Department of Public Health (CDPH), Department of Pesticide Regulation (DPR), DWR, USGS, and Lawrence Livermore National Laboratory (LLNL). In addition to groundwater quality data, GeoTracker GAMA has more than 2.5-million depth to groundwater measurements from the Water Boards and DWR, and also has oil and gas hydraulically fractured well information from the California Division of Oil, Gas, and Geothermal Resources. Table SR-5 provides agency-specific groundwater quality information. Additional information regarding assessment and reporting of groundwater quality information is furnished later in this report.

PLACEHOLDER Table SR-5 Sources of Groundwater Quality Information

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Land Subsidence Monitoring

Land subsidence has been shown to occur in areas experiencing significant declines in groundwater levels. Land subsidence investigations in the Sacramento River Hydrologic Region include monitoring efforts such as,

- Borehole extensometer monitoring, and
- GPS array monitoring.

A borehole extensometer is designed to act as benchmark anchored to a geologically stable portion of the lower aquifer. The first extensometer installed by DWR in the Sacramento River Hydrologic Region was in 1992; another was installed in 1994, and eight were installed in the early 2000s. In 1992, DWR began maintaining and monitoring an extensometer that USGS installed in 1988. The locations of the extensometers were based on geographic distribution in the center portion of the valley and where access to a site could be obtained. The extensometers range from 700 feet to over 1,000 feet deep within the unconsolidated sediments of the Sacramento Valley. DWR also measures groundwater levels in monitoring wells near each extensometer. Together, these data show a correlation between land subsidence and groundwater declines during the growing season, and land recovery as groundwater rises in winter.

In 2008, DWR, together with 20 federal, State, and local agencies, installed and surveyed a land elevation measurement network in the Sacramento Valley. The Sacramento Valley Height-Modernization Project provides accurate measurements of land surface elevations with GPS technology using a consistent vertical datum known as “NAVD88.” Land elevations were measured using the GPS survey equipment and survey monuments located on an approximate three to five mile grid. The GPS station network consists of 339 survey monuments spaced about seven kilometers apart, and covers all or part of 10 counties. The network extends from northern Sacramento County eastward to the USBR's Folsom Lake network, southwest to DWR's Delta/Suisun Marsh network, and north to USBR's Lake Shasta network. The network is scheduled to be re-surveyed on a three-year frequency to measure elevation changes over time.

The results from the subsidence monitoring are provided later in this report.

Ecosystems

Much of the natural ecosystem left in the Sacramento Region is based around the Sacramento River riparian corridor. The Sacramento River corridor (river channel and floodplain) is composed of several habitat types. The habitats evolve with changes in channel movement, hydrology, and the different stages of plant communities and include riparian forests, shady and bare eroding stream banks, sloughs, side channels, riparian grasslands, large woody debris and snags, and sand and gravel bars.

With respect to riparian plant communities, each plant community in the river corridor is a successional community or "stage" which leads to the establishment of the next successional stage, and so on, until a final stage or climax plant community develops. Over time, one plant community replaces another plant community and each serves a variety of wildlife species. The dynamic nature of the river system is the essential component of this diversity. As the course of the river changes and as plant communities evolve, both the species and the composition of plant and wildlife communities change. Geomorphic processes that support this regeneration and habitat diversity include river meander, sediment deposition of spawning gravels and point bars, and gradual accretion of the floodplain. These processes are the focus of several restoration efforts in the corridor.

Sacramento River Conservation Area Forum Handbook estimates that approximately 23,000 acres of riparian habitat and valley oak woodland remain within the corridor which is about 11 percent of the original habitat (SRCAFH, 2003). Over time, water development projects have altered natural geomorphic river processes resulting in a reduction of spawning habitat and fragmentation of riparian systems. With the construction of Shasta Dam, winter flows have lessened and summer flows are higher. Levees have also had a role in the pattern of flooding and sediment deposition along the river which has impacted plant community succession necessary for the natural establishment of riparian habitat. Other tributaries below Shasta Dam are unregulated and still contribute to flood flows necessary to aid in community succession.

There are four distinct reaches of the Sacramento River within the valley from Keswick Dam to Verona. The reaches are defined as follows:

- Keswick to Red Bluff
- Red Bluff to Chico Landing
- Chico Landing to Colusa
- Colusa to Verona

Each of the reaches are distinct from one another due to regional hydrology, geology, flood control measures, and habitat. The reach between Keswick Dam and Red Bluff is relatively confined due to geologic formations. Adjacent riparian vegetation is typically narrow. The floodplain is less than a mile wide and narrows to less than 500 feet in some places (SRCAF 2003). The reach of the river contains the only existing habitat for winter-run Chinook salmon. With the construction of Shasta and Keswick Dams and the elimination of an estimated 187 miles of habitat that were available upstream of the dams, winter-run salmon were reduced from four independent populations to one dependent population (NMFS 2003). Fish habitat was also impacted with the elimination of recruitment spawning gravels which is estimated to be on the order of 100,000 tons per year (Buer 1985). Since 1978, spawning gravel has been periodically replenished in the upper reaches of the river. CVPIA projects have also been implemented to increase the availability of spawning gravel and rearing habitat (CDFG 2011). With construction of the temperature control device at Shasta Dam and increased flows, this reach of river can provide optimal water temperatures.

Within the reach between Red Bluff and Chico Landing, the river meanders over a broad alluvial floodplain ranging between 1.5 to 4 miles wide and provides some of the remaining riparian habitat. The river is also constrained in some places by older, more consolidated and erosion-resistant formations. Several tributaries drain surrounding uplands within this reach and the Keswick to Red Bluff reach and contribute to flood flows necessary for riparian forest succession.

Within the Chico Landing to Colusa reach, setback levees control the release of flood water to adjoining basins through a system of weirs and bypasses. The setback levees allow for river meander creating extensive tracts of riparian vegetation. Stony Creek is the only tributary to the river.

The main channel of the Colusa to Verona reach is tightly leveed with much of the riparian vegetation existing as linear strips along the levees and levee berms. The river is essentially channelized. Most floodwater leaves the main channel through sloughs and weirs.

Flood

Flooding in the Sacramento River Hydrologic Region is typically slow-rise, flash, or stormwater flooding. In the Sacramento River Hydrologic Region, exposure to a 500-year flood event threatens approximately one in three residents, almost $65 billion of assets (crops, buildings, and public infrastructure), 1.2 million acres of agricultural land, and over 340 sensitive species. Also, almost 95 percent of Sutter County residents, more than 55 percent of Yuba and Yolo County residents, and more than 50 percent of agricultural land region wide are exposed to the 500 year flood event.

Early flood history most notably includes the 1861-1862 floods (the “Great Flood”). This flood was remarkable for the exceptionally high stages reached on most streams, repeated large floods, and prolonged and widespread inundation in the Sacramento River Basin. Lower elevations experienced heavy rain, and upper elevations received continuous snowfall. There were reports published during this flooding period describing the lower Sacramento River basin as one vast sea of water. Overflow from the American River led to the flooding of the city of Sacramento, causing loss of life and property, while flooding from the Sacramento River enveloped large sections of the lowlands around Colusa, severely damaging ranches and drowning or starving cattle. It was this flood that provided the impetus for raising the levees around the city of Sacramento.

Since 1950, several sizeable floods inundated the Sacramento River Hydrologic Region. The floods of 1955, 1964, 1967, 1969, 1970, and 1974 were all characterized by extremely large flows, including record flows at some locations. The Sacramento River Flood Control Project and other flood management programs had been implemented, and project levees, dams, reservoirs, and waterways were employed to control much of the flood flows through the Sacramento system. For a complete list of floods in the

Sacramento River Hydrologic Region refer to the California's Flood Future Report Attachment C: Flood History of California Technical Memorandum.

Climate

The northernmost area, mainly high desert plateau, is characterized by cold, snowy winters with only moderate rainfall, and hot, dry summers. The mountainous parts in the north and east typically have cold, wet winters with large amounts of snow providing runoff for summer water supplies. The Sacramento Valley floor has mild winters with less precipitation and hot, dry summers. Overall annual precipitation in the region generally increases from south to north and west to east. The snow and rain that fall in this region contribute to the overall water supply for the entire state.

Demographics

Population

The Sacramento River Hydrologic Region had a population of 2,983,156 people in the 2010 census, making it third only to the South Coast and San Francisco Bay Hydrologic Regions in population out of the 10 California hydrologic regions. The three largest cities are Sacramento, Roseville, and Redding. The region had a growth rate of 3.31 percent between 2006 and 2010 (98,714 people).

Tribal Communities

PLACEHOLDER Table SR-6 Federally Recognized Tribes in Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Federal Clean Water Act (CWA) Programs and Tribes

In the Sacramento River Hydrologic Region six federally recognized tribes are eligible for Section 319 program funding to implement approved programs and on-the-ground projects to reduce nonpoint source pollutions problems.

Big Valley Band of Pomo Indians; Cortina Indian Rancheria of Wintun Indians; Middletown Rancheria of Pomo Indians; Pit River Tribe; Redding Rancheria; and Robinson Rancheria of Pomo Indians.

Section 106 of the Clean Water Act allows tribes to address water quality issues by developing monitoring programs, water quality assessment, standards development, planning, and other activities intended to manage reservation water resources. In Sacramento River Hydrologic Region, seven tribes are involved in Section 106 programs and activities: Big Valley Band of Pomo Indians; Cortina Indian Rancheria of Wintun Indians; Elem Indian Colony of Pomo Indians; Middletown Rancheria of Pomo Indians; Redding Rancheria; Robinson Rancheria of Pomo Indians; and Pit River Tribe.

Tribes with two or more grants and consistently good performance may be eligible to apply for a Performance Partnership Grant (PPG). Four tribes have PPGs: Middletown Rancheria of Pomo Indians; Redding Rancheria; Robinson Rancheria of Pomo Indians; and Pit River Tribe.

Disadvantaged Communities

The geographic area of the Sacramento River hydrologic region encompasses all or portions of 20 different counties. Almost all counties have at least one community that qualifies as a disadvantaged community (DAC). DWR defines DACs as communities and neighborhoods (census-designated places) with an annual median household income of less than 80 percent of the statewide average (or incomes less than $48,706). A total of 282 communities are identified within the region of which 155 are defined as DAC's.

Counties where 50% or more of the communities within the region qualify as disadvantaged include Butte (53%), Colusa (78%), Glenn (80%), Lake (80%), Modoc (88%), Nevada (58%), Plumas (72%), Shasta (68%), Siskiyou (100%), Tehama (67%), and Yuba (64%). Mapping tools to identify disadvantaged communities can be found at http://www.water.ca.gov/irwm/grants/resourceslinks.cfm. The maps and GIS files are derived from the US Census Bureau's American Community Survey (ACS) and are compiled for the 5-year period 2006-2010.

Land Use Patterns

The Sacramento River Hydrologic Region between 2005 and 2010 supported about 1.95 million acres of irrigated agriculture on average. Approximately 1.58 million acres is irrigated on the valley floor. The surrounding mountain valleys within the region add about 370,000 irrigated acres to the region's total - primarily as pasture and alfalfa (see Table SR-7).

PLACEHOLDER Table SR-7 Irrigated Acreage Estimates

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Regional Resource Management Conditions

Water in the Environment

The focus of several federal, state, and local agencies in the region is the restoration of spawning and rearing habitats of the major rivers and tributaries and the recovery of listed species. Winter-run salmon are listed as endangered under the ESA. Spring-run salmon, steelhead, and green sturgeon are listed as threatened. The loss of habitat and the different life cycles of winter-run salmon, spring-run salmon, and steelhead require that available resources are managed to provide the most optimal conditions possible to lessen the possibility of extinction.

One of the key recovery/habitat restoration programs for the Sacramento River Region has been the Anadromous Fish Restoration Program (AFRP). The Anadromous Fish Restoration Program was established in 1992 under the CVPIA and supports protection, restoration, and enhancement of special status species and habitat that are affected by the CVP. The purpose of the program is to determine baseline production estimates for Central Valley Streams for naturally produced Chinook salmon and other anadromous species and to ensure their sustainability at levels not less than twice the average levels attained during the period of 1967 – 1991. The AFRP fish population goals are: fall run Chinook – 750,000, late-fall run Chinook – 68,000, winter run Chinook – 110,000, and spring-run Chinook – 68,000. During the period from 1967 to 1991, the total average annual fish population for all runs of Chinook was approximately 497,054. Since the enactment of AFRP, the total annual fish population for the period 1992 to 2010 was 410,790 – a decrease of almost 90,000 fish. This low population average is partially due to the 2010 fall run returns which totaled 102,735 fish. On the positive side, the watershed doubling goal was exceeded for Clear Creek, Butte Creek, and Battle Creek (USBR 2012). The six species identified for recovery under this program are Chinook salmon, steelhead, striped bass, American shad, white sturgeon and green sturgeon (USBR 2003).

Restoration/recovery projects that have been funded through AFRP include the temperature control device on Shasta Dam, removal of the McCormick-Saeltzer Dam on Clear Creek, spawning gravel replenishment, and most recently, the Red Bluff Diversion Dam Fish Passage Improvement. The Anadromous Fish Screen Program (another CVPIA program) supports the AFRP and has facilitated the screening of 33 priority diversions since 1994. Currently, there are about 750 unscreened diversions (agricultural and M&I) in the Sacramento River system (USBR 2011e).

The CALFED Ecosystem Restoration Program (ERP) is the principal CALFED program designed to restore the ecological health of the Bay-Delta and Central Valley. California Department of Fish and Game (CDFG) is the implementing agency for the State. The ERP and associated plans are discussed in more detail below.

Other planning that address the recovery of listed species is the NMFS Public Draft Recovery Plan for salmon and steelhead. The NMFS is required to evaluate factors affecting the species and identify recovery criteria and actions necessary to achieve recovery. The recovery plan, published in 2009, identifies site specific actions necessary for species recovery and provides measurable criteria necessary for delisting the species.

Another legislative mandate is the Instream Flow Studies Delta Reform Act of 2009 which requires the State Water Resources Control Board (SWRCB) to complete instream flow studies for high priority rivers and streams by 2018. The flow studies are intended to be based on what would be needed if fishery protection was the sole purpose for which waters were put to beneficial use.

Water Supplies

PLACEHOLDER Figure SR-10 Sacramento River Regional Inflows and Outflows in 2010

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Surface Supplies

CVP Water Supply

Most of the water delivered by CVP facilities in the Sacramento River Region is for agriculture use. Sacramento and Redding receive part of their water supply from CVP facilities. CVP water is delivered for agriculture and wildlife refuges through the Tehama-Colusa and Corning canals and is supplied from Red Bluff Diversion Dam on the Sacramento River. The canals serve about 160,000 acres of land in Tehama, Glenn, Colusa, and Colusa, and Yolo counties. CVP contractors and water rights settlement users also make direct diversions from the Sacramento River. The supplies listed include, where applicable, both project water and water rights settlement (base supply) water.

Releases from Folsom Reservoir on the American River serve Delta and CVP export needs and also provide supply agencies in the Sacramento metropolitan area.

Supply from Other Federal Water Projects

Monticello Dam in Napa County impounds Putah Creek to form Lake Berryessa, the principal water storage facility of USBR's Solano Project. The project provides urban and agricultural water supply to Solano County (partly in the Sacramento River region and partly in the San Francisco Bay region) and agricultural water supply to the University of California, Davis in Yolo County. Napa County uses about 1 percent of the supply for development around Lake Berryessa.

Orland Project

There are three reservoirs on Stony Creek north of Lake Berryessa. Two of these are East Park (1909) and Stony Gorge (1928) built on upper Stony Creek. Presently, their supply irrigates small acreages of land in Colusa and Glenn counties before becoming part of the water supply in Black Butte Reservoir. About 100 thousand acre-feet is released from Black Butte Reservoir for irrigation in Glenn County.

SWP Water Supply

Lake Davis, Frenchman Lake, and Antelope Lake are on Feather River tributaries in Plumas County and are used primarily for recreation, but also supply water to the City of Portola and local agencies that have water rights agreements with the California Department of Water Resources (DWR). Lake Oroville and Thermalito Afterbay also supply the region. Local agencies that receive water rights delivered through Thermalito Afterbay include Western Canal Water District, Richvale Irrigation District, Biggs-West Gridley Water District, Butte Water District, and Sutter Extension Water District. Agencies in the region holding long-term contracts for SWP supply are Plumas County Flood Control and Water Conservation District (FCWCD), Butte County, Yuba City, and Solano County Water Agency. SCWA receives its SWP supply from the Delta through the North Bay Aqueduct.

Local Surface Water Supply

Water stored and released from Clear Lake and Indian Valley Reservoir into Cache Creek is diverted by the Yolo County FCWCD for irrigation in Yolo County. Since 1950, the district has diverted an average of 130 thousand acre- feet annually at Capay Diversion Dam on lower Cache Creek. No water supply from these sources was available during the 1977 and 1990 drought years. In Sutter County and in western Placer County, South Sutter Water District (SSWD) supplies irrigation water from Camp Far West Reservoir on the lower Bear River. SSWD also purchases surface water from Nevada Irrigation District to supplement irrigators' groundwater supplies. NID's supplies come from its reservoir on the Yuba-Bear River system. Yuba River supplies have also been developed by Yuba County Water Agency, which is New Bullards Bar Reservoir, the river's largest reservoir at 966 thousand acre-feet. The Sacramento metropolitan area, served by more than 20 water purveyors, is the largest urban area in the Sacramento River Hydrologic Region and is also the largest urban surface water user. Within Sacramento County, the City of Sacramento relies primarily on surface water (approximately 80 to 90 percent); water purveyors in unincorporated areas use both surface water and groundwater. The City of Sacramento diverts its CVP water supply from the American River at H Street and also diverts downstream from the confluence of the American and Sacramento rivers. The City of Folsom takes surface water from Folsom Lake.

Groundwater

The Sacramento Valley Groundwater Bain in the region is recognized as one of the foremost groundwater basins in the state, and wells developed in the sediments of the valley provide sufficient supply to irrigation, municipal, and domestic uses. Geologically, the valley is a large trough filled with sediments having variable permeabilities; as a result, wells developed in areas with coarser aquifer materials will produce larger amounts of water than will wells developed in fine aquifer materials. In general, well yields are good and range from 100 gallons per minute to several thousand gallons per minute. Because surface water supplies have been so abundant in the valley, groundwater development for agriculture for the most part has been used to supplement the primary surface supply. Many of the mountain valleys of the region also provide significant groundwater supplies for multiple uses.

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

Groundwater supply is reported by water year (October 1 through September 30) and categorized according to agriculture, urban, and managed wetland uses. The associated information is presented by planning area (PA), county, and by the type of use. Reference to total water supply represents the sum of surface water and groundwater supplies in the region, and local reuse.

2005-2010 Average Annual Groundwater Supply and Trend

With a 2005-2010 average annual extraction volume of 2.7 million acre-foot (maf), groundwater pumping in the Sacramento River Hydrologic Region accounts for 17 percent of all the groundwater extraction in California – the third highest among the 10 hydrologic regions in California, behind Tulare Lake Hydrologic Region with 38 percent and San Joaquin River Hydrologic Region with 19 percent of the total.

Table SR-8 provides the 2005-2010 average annual groundwater supply by PA and by type of use, while Figure SR-11 depicts the PA locations and the associated 2005-2010 groundwater supply in the region. The estimated average annual 2005-2010 total water supply for the region is about 9.0 maf. Out of the 9.0 maf total supply, groundwater supply is 2.7 maf and represents 30 percent of the region's total water supply; 47 percent (0.4 maf) of the overall urban water use and 30 percent (2.3 maf) of the overall agricultural water use being met by groundwater. Thus more than 84 percent of the groundwater supply in the region is used to meet agricultural water use, while only 16 percent are used to meet urban water use, respectively (2.3 maf versus 0.4 maf); groundwater contributes marginally to the supply required for meeting managed wetland uses in the region (20 taf).

PLACEHOLDER Table SR-8 Sacramento River Hydrologic Region Average Annual Groundwater Supply by Planning Area and by Type of Use (2005-2010)

PLACEHOLDER Figure SR-11 Contribution of Groundwater to the Sacramento River Hydrologic Region Water Supply by Planning Area (2005-2010)

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As shown in Table SR-8 and Figure SR-11, the largest groundwater PA in the region, Butte-Sutter-Yuba PA rely on more than 566 taf of groundwater pumping to meet 21 percent of the agricultural water use and 69 percent of the urban water use. The annual pumping volumes and reliance on groundwater supplies are also relatively high in Colusa Basin (521 taf) and Central Basin West (520 taf) PAs. Incidentally, Butte-Sutter-Yuba, Colusa Basin, and Central Basin West PAs are also the three largest users of groundwater for agricultural use in the region (508, 498, and 473 taf, respectively). Among the various PAs in the region, Colusa basin is 100 percent dependent on groundwater supply to meet its urban water use. The Central Basin East PA includes several urban centers including the City of Sacramento, and is the largest user of groundwater for urban use in the region (186 taf annually), which is more than triple the next highest user of groundwater for urban use in the PAs of the region. Although on average only 47 taf of groundwater is pumped annually in Southwest PA, it relies on groundwater for 77 percent of its total water supply.

Regional totals for groundwater based on county area will vary from the PA estimates shown in Table SR-8 because county boundaries do not necessarily align with PA or hydrologic region boundaries. Of the 22 counties located completely or partially within the Sacramento River Hydrologic Region, 17 counties were included in the analysis of groundwater supply for the region. Butte, Colusa, Glenn, Lake, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Solano, Sutter, Tehama, Yolo, and Yuba counties are fully or mostly contained within the region, while El Dorado and Modoc Counties are partially contained within the region; groundwater supplies are reported for these 17 counties (see Table SR-9). Groundwater supplies for other five partially contained counties in the region - Alpine, Amador, Lassen, Napa, and Siskiyou - are discussed in the regional reports of the relevant hydrologic regions. Overall, groundwater contributes to about 31 percent of the total water supply for the 17-county area; the range varies from 13 to 75 percent for individual counties. Although most of the groundwater extraction in the 17-county area occurs for agricultural water use (2.4 maf), groundwater supplies meet about one-thirds of the agricultural water use. In contrast, although overall groundwater extraction for urban water use is significantly less (465 taf), groundwater supplies meet about half of the urban water use. Groundwater supply contribution is marginal for meeting managed wetlands use in the 17-county area.

More detailed information regarding groundwater water supply and use analysis is available online from Update 2013, Volume 4, Reference Guide, the article "California's Groundwater Update 2013."

PLACEHOLDER Table SR-9 Sacramento River Hydrologic Region Average Annual Groundwater Supply by County and by Type of Use (2005-2010)

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

Figures SR-12 and SR-13 summarize the 2002 through 2010 groundwater supply trends for the Sacramento River Hydrologic Region. The right side of Figure SR-12 illustrates the annual amount of groundwater versus total water supply, while the left side identifies the percent of the overall water supply provided by groundwater relative to total water supply. The center column in the figure identifies the water year along with the corresponding amount of precipitation, as a percentage of the 30-year running average for the region. Figure SR-13 shows the annual amount and percentage of groundwater supply trends for meeting urban, agricultural, and managed wetland uses.

PLACEHOLDER Figure SR-12 Sacramento River Hydrologic Region Annual Groundwater Supply Trend (2002-2010)

PLACEHOLDER Figure SR-13 Sacramento River Hydrologic Region Annual Groundwater Supply Trend by Type of Use (2002-2010)

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Figure SR-12 indicates that the annual water supply for the region has fluctuated between 2002 and 2010 depending on annual precipitation amounts. Between 2002 and 2010, annual water supply fluctuated between 8.3 maf and 9.9 maf. Figures SR-12 and SR-13 indicate that during the same period, groundwater supply has fluctuated between 2.4 maf and 3.1 maf, and provided between a fairly stable 28 and 32 percent of the total water supply for the region. The wet water years of 2005 and 2006 saw the least amount of groundwater pumped at about 2.5 maf each year. Conversely, during the dry years of 2007, 2008 and 2009 groundwater extraction, in response to cutbacks in surface water deliveries in the region, increased to about 3.0 maf each year.

Figure SR-13 indicates that groundwater supply meeting agricultural use ranged from 81 to 87 percent of the annual groundwater extraction while groundwater supply meeting urban use ranged from 13 to 19 percent of the annual groundwater extraction, with only one percent of the groundwater extraction meeting managed wetland uses. During the dry years of 2007, 2008, and 2009, groundwater pumping for agricultural use increased by about 500 TAF when compared to the wet years that preceded and followed the dry years (2.5 maf versus 2.0 maf). The increase in groundwater extraction is attributed to a combination of increased irrigation demand and reduced surface water deliveries during these consecutive dry years. Groundwater pumping to meet urban water use remained fairly stable during 2002 to 2010 period ranging from about 370 to 480 TAF.

Water Uses

Water use in the Sacramento River region is mostly for agricultural production with more than 2 million irrigated acres in the year 2000. Agricultural products include a variety of crops such as rice and other grains, tomatoes, field crops, fruits and nuts. A substantial number of acres of rangeland in this region are also used for livestock management. Much of the economy of the region relies on agricultural water supplies, which are diverted and distributed through extensive systems of diversion canals and drains. Basinwide, water use efficiency is generally high because many return flows from fields are captured by drainage systems and then resupplied to other fields downstream.

Water Conservation Act of 2009 (SB x7-7) Implementation Status and Issues

Thirty-five Sacramento River urban water suppliers have submitted 2010 urban water management plans to DWR. The Water Conservation Law of 2009 (SBx7-7) required urban water suppliers to calculate baseline water use and set 2015 and 2020 water use target. Based on data reported in the 2010 urban water management plans, the Sacramento River Hydrologic Region had a population-weighted baseline average water use of 271 gallons per capita per day and an average population-weighted 2020 target of

219 gallons per capita per day. The Baseline and Target Data for the individual Sacramento River urban water suppliers is available on the Department of Water Resources (DWR) Urban Water Use Efficiency website.

The Water Conservation Law of 2009 (SBx7-7) required agricultural water suppliers to prepare and adopt agricultural water management plans by December 31, 2012, and update those plans by December 31, 2015, and every 5 years thereafter. Five 2012 agricultural water management plans have been submitted to DWR, representing 13 Sacramento River agricultural water suppliers.

Water Balance Summary

The Sacramento River Hydrologic Region has eleven planning areas that range from sparsely populated mountainous areas to areas with populous major cities. See Table SR-10 Water Balance Summary and Volume 5 (Technical data) for more information on the water balances and portfolios.

PLACEHOLDER Table SR-10 Sacramento River Hydrologic Region Water Balance Summary, 2001-2010

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The Shasta Pit Planning Area (PA501) averages about 17 TAF per year urban applied water. Agricultural applied water ranges from about 325 to 425 TAF per year. Managed wetlands use has decreased from about 13 TAF to 10 TAF per year. The McCloud River has a special Wild and Scenic River designation that wasn’t included in Update 2005 (water year 2001), but was included in subsequent years. This flow, which ranges from 950 to 1,865 TAF per year, is reused downstream.

Supply for the Shasta Pit Planning Area is primarily local supply and reuse from the McCloud River, with about 100 acre-feet of groundwater extracted annually.

The Upper Northwest Valley Planning Area (PA 502) urban use is generally less than 1 TAF per year. Agricultural applied water ranges from 6.5 to over 13 TAF per year. There are no managed wetlands or instream environmental water use. Surface water consists of local deliveries (4-10 TAF per year), Central Valley Project deliveries (1 to less than 2 TAF) and reuse (0.5-1.3 TAF). Until 2008, generally less than 2 TAF of groundwater was extracted; from 2008 to 2010, the amount increased to about 5 TAF per year.

The Lower Northwest Valley Planning Area (PA 503) urban applied water is about 60 TAF per year. About half of the urban use is industrial and commercial. Agricultural applied water ranges from about 450 to more than 600 TAF per year. Instream requirements the Lower Northwest Planning Area total about 2.2 MAF per year which leaves the planning area, but is reused downstream. About 200 acre-feet per year is applied to managed wetlands.

Supplies in the Lower Northwest Valley Planning area consist primarily of CVP deliveries in years when CVP water is available. In years when CVP water is not available, local sources are used. In addition, 250 to 360 TAF of groundwater is extracted each year.

The Northeast Valley Planning Area (PA 504) urban use is about 70-85 TAF, which is primarily residential. Agricultural use ranges from 250 to 350 TAF per year. Managed wetlands use about 1 TAF per year and there is no instream environmental. Supplies are about half surface water (local, reuse and CVP) and half groundwater.

The Southwest Planning Area (PA505) has about 10 to 11 TAF in urban applied water and 51 to 67 TAF in agricultural applied water. There is no environmental water use in this planning area. Surface water supplies (local deliveries and reuse, with a little CVP water) constitute about one-third to one-half of the supply, with groundwater extractions making up the difference.

The Colusa Basin Planning Area (PA 506) is primarily agricultural; with 2.1 to 2.7 MAF of agricultural applied water and only about 12-15 TAF of urban applied water. There are significant managed wetlands here (160-175 TAF per year) that are primarily associated with rice farming. Supplies are primarily surface water with most coming from the Central Valley Project deliveries and reuse. About 460-600 TAF of groundwater are also extracted.

The Butte-Sutter-Yuba Planning Area (PA 507) is similar to the Colusa Basin Planning Area, but with more urban, managed wetlands and agricultural use overall. There is also some instream environmental water (800 TAF to 1 MAF per year) that is reused with the same planning area. Groundwater supplies are about the same as in PA 506, with surface water supplies being primarily local deliveries. CVP and State Water Project deliveries total about 150 to 450 TAF per year. There is also significant reuse of surface water supplies.

The Southeast Planning Area (PA 508) covers the northern part of the Mountain Counties subarea. It has some urban and agricultural areas within its mountainous terrain. There are about 100 to 133 TAF of urban applied water and 330 to 400 TAF per year of agricultural applied water. There are generally 1.9 to 4.4 MAF of combined instream and wild and scenic applied water, most of which is reused downstream with the same planning area. There are some managed wetlands in which use varies from 1 to 17 TAF per year.Water supplies are primarily surface water (local deliveries and reuse of instream environmental water) with about 50 to 60 TAF of groundwater extracted.

The Central Basin West Planning Area (PA 509) is also primarily agricultural in nature, with 55 to 80 TAF in urban use and 750 TAF to 1 MAF of agricultural applied water. There are about 22 to 30 TAF per year in instream flows and occasionally some managed wetlands use. Supplies are about half surface water (local deliveries, CVP, other federal deliveries, SWP and reuse) and half groundwater.

The Sacramento Delta Planning Area (PA 510) covers most of the Sacramento-San Joaquin Delta area that lies north of the confluence of the Sacramento and San Joaquin Rivers. There are about 20 to 40 TAF urban applied water and 400 to 700 TAF agricultural applied water in this planning area. Managed wetlands use about 15 to 60 TAF per year.

This is the planning area wherein the Required Delta Outflow for the state is measured. The amounts are statutorily set and are dependent upon water year type in the Sacramento River and San Joaquin River Regions. In our ten year study period, amounts ranged from 4.5 to 10.1 MAF per year. Supplies are primarily local surface water and inflows from other regions, with less than 40 TAF per year of groundwater extracted.

The Central Basin East Planning Area (PA 511) is the most metropolitan area in the hydrologic region, with between 380 and 480 TAF per year in urban applied water. Agricultural applied water ranges from 430 to 520 TAF per year. Managed wetlands use less than 2 TAF per year in applied water. Instream requirements use about 235 TAF per year and wild and scenic rivers 7 to 40 TAF, all of which is reused downstream.

Thirty to forty percent of the water is supplied by groundwater pumping and the rest is a combination of local surface water, CVP deliveries and reuse.

See Figure SR-14 for the Sacramento River region water balance summary.

PLACEHOLDER Figure SR-14 Sacramento River Regional Water Balance by Water year, 2001-2010

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Project Operations

The Bureau of Reclamation (USBR) and DWR operate the Central Valley Project (CVP) and the State Water Project (SWP) in accordance with a Coordinated Operations Agreement authorized by Congress though Public Law 99-546 in 1986. This agreement defines the rights and responsibilities of the CVP and SWP with respect to in-basin water needs and provides a mechanism to account for those rights and responsibilities. The agreement also works to provide coordinated operations for balanced conditions for the Sacramento Valley and the Delta while meeting water supply needs. "Balanced conditions" are defined as periods when releases from upstream reservoirs and unregulated flow approximate the water supply needed to meet Sacramento Valley in-basin uses and CVP/SWP exports (NMFS 2009).

Balanced conditions are further defined by biological opinions, SWRCB D-1641, SWRCB D-1485, and CVPIA 3406(b)(2). The 1993 NOAA Biological Opinion (BO) imposed operational constraints on the projects and introduced a combined CVP/SWP incidental take for Delta export facilities. The 2009 BO established in-stream temperature requirements, temperature management plans, end-of-September storage requirements, and restoration goals for the CVP. SWRCB D-1641 requirements include X2 standards, export/inflow ratios, and other operational requirements. SWRCB D-1485 ordered the CVP and SWP to guarantee water quality protection for agricultural, municipal and industrial (M&I), and fish and wildlife uses.

The CVP was first authorized in 1935 and reauthorized in 1992 through the Central Valley Project Improvement Act (CVPIA). The CVPIA modified the original 1937 act and added mitigation, protection, and restoration of fish, wildlife, and associated habitats as a project purpose. The act specified that the dams and reservoirs of the CVP be used: "first, for river regulation, improvement of navigation, and flood control; second, for irrigation, and domestic uses and fish and wildlife mitigation, protection, and restoration purposes; and third, for power and fish and wildlife enhancement."

The CVPIA also dedicated water to fish, wildlife, and habitat restoration on an annual basis. Of this amount, 800,000 acre-feet was dedicated to environmental needs as Section 3406(b)2 water, 200,000 acre-feet was designated for wildlife refuges, and 200,000 acre-feet was dedicated for increased Trinity River flows for fisheries restoration. Flexibility in project operations provides some of the dedicated water; however, the dedications also result in a reduction of CVP contractor water of 516,000 acre-feet per year on average and 585,000 acre-feet in dry years (USBR 2011a).

The goals and objectives mandated by the water quality plans, decisions, regulatory requirements, and hydrologic conditions complicate project operations and the ability to meet all water demands. Meeting water demands are further complicated under future climate change scenarios and the related uncertainties of water supplies. The following provides an overview of the projects and operational requirements.

The Central Valley Project

Shasta and Keswick Dams

Shasta Dam is the primary storage and power generating facility of the CVP. The watershed above dam drains approximately 6,650 square miles and has an average annual runoff of 5.7 maf. Shasta Lake has a capacity of approximately 4.5 maf. Annual releases from the dam range from 9 maf in wet years to 3 maf in dry years. Construction of temperature control facilities at the dam in 1997 enables the release of water from different levels of storage to help meet temperatures requirements downstream of Keswick Dam. Keswick Reservoir serves as an afterbay for releases from Shasta Dam and has a capacity of approximately 23,800 acre-feet. The dam also controls runoff from about 45 square miles of drainage area.

Operations at Shasta and Keswick dams are required to meet certain objectives and performance measures that affect flood control, water supply, water quality, riparian habitat, and the survival of several species within the Sacramento River. Flood control objectives for Shasta Lake require that releases be restricted to a flow of 79,000 cfs at Keswick Dam and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station corresponding to a flow of approximately 100,000 cfs. A critical factor of flood operations is the amount of runoff entering the Sacramento River from Cottonwood Creek, Cow Creek, and Battle Creek. During rainfall events, local runoff between Keswick Dam and Bend Bridge can exceed 100,000 cfs (USBR 2004).

A storage space of up to 1.3 maf below full pool at the lake is kept available for flood management purposes. From December 23 to June 15, the required flood management space varies based on seasonal inflow. Daily flood management operations consist of determining the required flood storage space reservation and scheduling releases in accordance with flood operations criteria. The goal of existing operations is to have vacant flood storage space in excess of flood requirements and then fill the pool to the maximum extent possible for water supplies for the remainder of the year (USBR 2011a).

Historically, minimum navigation flows at Chico Landing were set at 5,000 cfs. This flow for navigation is no longer kept; however, water diverters have set their pump intakes just below this associated water level elevation. For this reason CVP has been operated to meet the navigation flow requirement of 5,000 cfs to Wilkins Slough under most water supply conditions. At flows less than 5,000 cfs, water diversion operations become impacted. At 4,000 cfs, some pumps become inoperable (McInnis 2011).

The flow objectives established for the Sacramento River at Rio Vista require minimum monthly average flows of: 3,000 cubic per second (cfs) during September of all year types, 4,000 cfs during October of all year types except critical years when flows of 3,000 cfs are required, and 4,500 cfs during November through December of all year types except critical years when flows of 3,500 cfs are required. The objective also requires that the 7-day running average flow is not less than 1,000 cfs below the monthly objective.

2009 Biological Opinion for Shasta Operations

With respect to water quality and habitat for salmon and steelhead, the 2009 BO for Shasta operations identified several objectives to avoid adverse effects on winter-run and spring-run salmon (McInnis 2011):

- Ensure a sufficient cold water pool to provide suitable temperatures for winter-run spawning between Balls Ferry and Bend Bridge in most years without sacrificing the potential for cold water management in a subsequent year
- Ensure suitable spring-run temperatures regimes, especially in September and October
- Establish a second population of winter-run salmon in Battle Creek
- Restore passage at Shasta Reservoir with experimental reintroductions of winter-run salmon to the upper Sacramento and/or McCloud rivers.

Actions to realize some of the above objectives focus on the End-of-September (EOS) Shasta Reservoir carryover storage. The storage capacity of Shasta Reservoir is approximately 4.5 maf. EOS storage objectives have been set at 2.2 maf and 3.2 maf to be met 87 percent and 40 percent of the time respectively. EOS storage is at 2.4 maf about 70 percent of the time. The EOS storage requirement of 2.2 maf is set to provide the water necessary to meet the minimum Balls Ferry temperature requirements for the following year (McInnis 2011).

Performance measures have also been established for water temperature at Clear Creek, Balls Ferry, Jelly's Ferry, and Bend Bridge compliance points. From April 15 to September 30, water temperatures are not to exceed 56 degrees Fahrenheit between Balls Ferry and Bend Bridge. From October 1 and October 31, water temperatures are not to exceed 60 degrees Fahrenheit provided conditions are sufficient to support and sustain compliance.

A fall monthly release schedule is required to be developed by November 1st of each year based on EOS and hydrologic projections. Release schedules are based on habitat needs, flood control needs (a maximum end-of-November storage volume of 3.25 maf is necessary for flood control), Bay/Delta water quality requirements, and conservation of storage for next year's cold water pool. If EOS is below 1.9 maf, Keswick releases will be reduced to 3,250 cfs unless higher releases are necessary to maintain temperature compliance points (McInnis 2011).

To conserve water in storage in the spring, USBR is required to make its February 15 forecast of deliverable water based on an estimate of precipitation and runoff at a 90 percent probability of exceedence. NMFS reviews the draft forecast to determine whether both a temperature compliance point at Balls Ferry (from May to October) and EOS storage of at least 2.2 maf can be achieved. Release schedules are then devised based on temperature compliance points, EOS requirements, nondiscretionary delivery obligations, and legal requirements (McInnis 2011). USBR is required to develop and implement an annual Temperature Management Plan by May 15 of each year for the period of May 15 through October 31 to manage cold water supplies within the Shasta Reservoir and Spring Creek to provide suitable temperatures for listed species.

PLACEHOLDER Box SR-2 Shasta Lake Water Resources Investigation (SLWRI) – Enlarging Shasta Dam and Reservoir

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Trinity River Diversion

In 1955, Congress authorized the construction of Lewiston and Trinity Dams on the Trinity River creating the Trinity River Diversion (TRD) for the export of water into the Central Valley. Operations of the TRD began in 1964 and were integrated with operations of Shasta Dam. Exports from TRD help to meet minimum flow requirements in the Trinity and Sacramento rivers, help to maintain reservoir storage levels, and facilitate operational compliance for water temperature below Keswick Dam.

Prior to construction of TRD, average annual discharge at Lewiston was approximately 1.2 maf with peak flows in excess of 100,000 cfs being recorded. Following construction of the dam, instream flow releases were set at 120,500 af/yr (10 percent of the average unimpaired flow). From 1964 to 1996, TRD exports accounted for 14 percent of Keswick releases (USFWS 1999). An outcome of TRD operations and the reduced instream flows of the Trinity River has been the degradation of fish habitat and reductions in anadromous fish populations. By 1980 it was estimated that fish populations had been reduced by 60 to 80 percent due to inadequately regulated harvest, excessive streambed sedimentation, and insufficient streamflow. The loss of fishery habitat was estimated to be 80 to 90 percent. To help address these problems, Congress passed the Trinity River Stream Rectification Act in 1980 (addressing sedimentation issues) and passed the Trinity River Basin Fish and Wildlife Management Act in 1984. The 1984 act directed efforts to restore fish and wildlife populations to levels that existed prior to TRD construction.

One of the provisions of the CVPIA was the establishment of a minimum flow volume for the Trinity River of 340,000 af. The CVPIA also directed the completion of a 12-year study (Trinity River Flow Evaluation Study (TRFES)) to establish permanent instream fishery flow requirements, operating criteria, and procedures for restoration and maintenance of the fishery (USFWS 1999). SWRCB Order 90-5 set temperature objectives for each reach of the river by season. The TRFES report recommended specific annual flow releases, sediment management, and channel rehabilitation to provide necessary habitat.

The Trinity River ROD of 2000 reduced the average annual export of the Trinity River to the Keswick Reservoir from 74 percent to 52 percent of flow. Since 2003, Trinity River restoration efforts have included improvements to floodplain infrastructure, channel rehabilitation, and peak flow releases. Since 2004 peak flow releases have ranged from 4,419 cfs to 10,100 cfs. Total annual flows have increased to a range of 368,600 to 452,600 af. Proposed future annual flows range from 368,600 to 815,000 af.

Sacramento River Division

The Sacramento River Division was authorized in 1950 to supply irrigation water to Tehama, Glenn, Colusa, and Yolo Counties. The unit consists of Red Bluff Diversion Dam (RBDD), Funks Dam, Corning Pumping Plant, Tehama-Colusa Canal (TCC), and the Corning Canal. Both canals provide irrigation water to approximately 100,000 acres. The TCC also provides water for about 20,000 acres of the Sacramento Valley Refuges. The division contains 18 water contractors. Each contractor has its own service contract with USBR which were renewed in 2005.

Construction of the RBDD was completed in 1964. Historically the gates of the dam were lowered by May 15th of each year creating Lake Red Bluff and raised on September 15th to allow for river flow through. The dam has had issues with fish passage and agricultural water diversion reliability since its construction and has impeded both the upstream migration of audit fish to spawning habitat and the downstream migration of juveniles impacting both winter-run and spring-run Chinook salmon (McInnis 2009). Upstream of the diversion dam is also critical spawning and holding habitat for green sturgeon. To facilitate fish passage, the NMFS 2009 Biological Opinion for the RBDD required that dam gates to be raised year-round by the year 2012. The diversion now includes a 2,500 cfs pumping plant and flat-plate fish screen to the existing canal headworks to replace the loss of the diversion structure.

American River Division

The American River Division of the Central Valley Project provides water for irrigation, municipal and industrial use, hydroelectric power, and recreation. It consists of the Folsom, Sly Park, and Auburn-Folsom South Units. The division is about midway between the northern and southern extremes of the Central Valley in Sacramento, San Joaquin, Placer, and El Dorado Counties. Division lands stretch from Sugar Pine Dam in the north to Stockton in the south. Most lands served by the Division lie in the southern portion of the Division, between Sacramento and Stockton.

In addition, units of the American River Division provide a high degree of flood control along the American River, protecting several communities including the California capital city of Sacramento. The American River Division consists of the Folsom, Sly Park, and Auburn-Folsom South Units.

The Folsom and Sly Park Units, though separate units of the American River Division, are often referred to together due to the fact that both units were authorized as part of the Central Valley Project by the same legislation.

The Sly Park Unit is made up of Sly Park Dam and Jenkinson Lake, Camp Creek Diversion Dam and Tunnel, and Camino Conduit and Tunnel. These provide municipal and industrial water for the nearby community of Placerville, and irrigation water for the El Dorado Irrigation District. Camp Creek Diversion Dam diverts a portion of the flow of Camp Creek to Jenkinson Lake via Camp Creek Tunnel, and Camino Tunnel and Conduit delivers water from Jenkinson Lake to the El Dorado Irrigation District for irrigation and municipal use. All features of the Folsom and Sly Park Units are complete and in operation.

The Folsom Unit consists of Folsom Dam and Lake, Folsom Powerplant, Nimbus Dam and Lake Natoma, Nimbus Powerplant, and Nimbus Fish Hatchery. Folsom Dam and Powerplant regulate the flow of the American River and provide water and power for municipal and industrial uses. Nimbus Dam and Lake Natoma act as an afterbay feature, regulating the outflows from the Folsom Powerplant. In addition, the Nimbus Powerplant provides supplemental electrical power to the area. The Nimbus Fish Hatchery compensates for the loss of salmon and trout spawning areas that were destroyed by construction of the dam. The lakes created by Folsom and Nimbus Dams provide recreation to thousands of people year round.

Authorized in 1965, the Auburn-Folsom South Unit originally consisted of Auburn Dam, Reservoir, and Powerplant, County Line Dam and Reservoir, Sugar Pine Dam and Reservoir, and the Folsom South Canal. The Auburn-Folsom South Unit was designed to provide a new and supplemental water supply for irrigation and municipal and industrial needs and to alleviate the badly depleted groundwater conditions in the Folsom South service area. It was about one third complete when construction was halted .

The completed portions of the project, Sugar Pine Dam and Reservoir, provide water for irrigation and municipal and industrial uses to the Foresthill Divide area.

The American River Division supplies water to several large municipal purveyors, including El Dorado ID, Foresthill PUD, Cities of Folsom, Roseville, Carmichael, Sacramento, as well as San Juan and Sacramento Suburban Water Districts.

Folsom and Nimbus Dams

The American River Division of the Central Valley Project provides water for irrigation, municipal and industrial use, hydroelectric power, and recreation. It consists of the Folsom, Sly Park, and Auburn-Folsom South Units. The division is about midway between the northern and southern extremes of the Central Valley in Sacramento, San Joaquin, Placer, and El Dorado Counties. Division lands stretch from Sugar Pine Dam in the north to Stockton in the south. Most lands served by the Division lie in the southern portion of the Division, between Sacramento and Stockton.

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The Folsom Unit consists of Folsom Dam and Lake, Folsom Powerplant, Nimbus Dam and Lake Natoma, Nimbus Powerplant, and Nimbus Fish Hatchery. Folsom Dam and Powerplant regulates the flow of the American River and provides water and power for municipal and industrial uses. Nimbus Dam and Lake Natoma act as an afterbay feature, regulating the outflows from the Folsom Powerplant. In addition, the Nimbus Powerplant provides supplemental electrical power to the area. The Nimbus Fish Hatchery compensates for the loss of salmon and trout spawning areas that were destroyed by construction of the dam. The lakes created by Folsom and Nimbus Dams provide recreation to thousands of people year round.

Authorized in 1965, the Auburn-Folsom South Unit originally consisted of Auburn Dam, Reservoir, and Powerplant, County Line Dam and Reservoir, Sugar Pine Dam and Reservoir, and the Folsom South Canal. The Auburn-Folsom South Unit was designed to provide a new and supplemental water supply for irrigation and municipal and industrial needs and to alleviate the badly depleted groundwater conditions in the Folsom South service area. It was about one third complete when construction was halted .

The completed portions of the project, Sugar Pine Dam and Reservoir, provide water for irrigation and municipal and industrial uses to the Foresthill Divide area.

The American River Division supplies water to several large municipal purveyors, including El Dorado ID, Foresthill PUD, Cities of Folsom, Roseville, Carmichael, Sacramento, as well as San Juan and Sacramento Suburban Water Districts.

State Water Project

The SWP delivers water from northern California to users in the lower Sacramento Valley, San Francisco Bay area, San Joaquin Valley, and southern California. The DWR Oroville Field Division operates and maintains the facilities extending from Feather River lakes in Plumas County to the Oroville-Thermalito Complex on the Feather River. The facilities include three power plants, a fish hatchery, and a visitor's center. DWR operates the facility for water supply, power generation, recreation, fish and wildlife enhancement, and salinity control.

Lake Oroville has a storage capacity of 3,538,000 acre feet that is fed by the North, Middle, and South Forks of the Feather River. Average annual unimpaired flow into the lake is approximately 45 million acre feet. Local diversions are made directly from the Thermalito Afterbay by irrigation districts with water rights senior to the SWP. Oroville Dam provides up to 750,000 acre feet of flood control space.

DWR has operated the Oroville facilities under a license issued by the Federal Power Commission (FERC No. 2100-134) that expired on January 31, 2007. Prior to the expiration, DWR filed for a new license with the Federal Energy Regulatory Commission (FERC) for continued operation of the facility. On March 24, 2006, DWR filed a settlement agreement with FERC for a new license for up to 50 years. DWR currently operates the Oroville facilities pursuant to an annual license by FERC. The SWP generates about half of the power it uses to move water throughout the State.

Project Water Supplies

Estimated 2001 demands for CVP water are about 3.4 maf for the Sacramento Basin and 3.5 maf for Delta export areas (USBR 2004). DWR 2002 estimates the delivery for SWP water to be about 3.0 maf. Seventy percent of SWP water is supplied for M&I use providing water to about two-thirds of the State's population; the remaining 30 percent goes to agriculture - about 750,000 acres in San Joaquin Valley (CDWR 2007a). Estimated water demands for CVP and SWP water for the Sacramento Valley, Delta, and south of the Delta are summarized in Table SR-11 below.

PLACEHOLDER Table SR-11 Estimates of Annual CVP/SWP Water Demand by Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

A breakdown of CVP water deliveries by water user is summarized below in Table SR-12.

PLACEHOLDER Table SR-12 Estimates of CVP Deliveries by Water User (million acre-feet)

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With the passage of the CVPIA, fish and wildlife share coequal priority with other water users. One of the mandates of the act is for 800,000 acre feet of water to be left instream annually for fish, wildlife, and habitat restoration. In dry and critical water years, when deliveries to agricultural service contractors north of the Delta are reduced, this water can be reduced by up to 100,000 af. This water can be reduced by up to 200,000 af in critically dry water years (USBR 2011c). Another of the act's provisions was establishment of the Refuge Water Supply Program to meet the needs of 19 federal, State, and private wildlife refuges. Up to 555,515 acre-feet is to be supplied annually to refuges with 80 percent of the water provided by CVP supplies. During dry year conditions, this source of water can be reduced by a maximum of 25 percent.

PLACEHOLDER Box SR-3 The Monterey Agreement

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

CVP/ SWP Supply Reliability

Water availability in the Central Valley is dependent on hydrologic conditions and operational needs of the Sacramento Valley and the Bay-Delta. The allocation of CVP water for any given water year is based on forecasted reservoir inflows, amounts of water in storage, regulatory requirements, and management of CVPIA Section 3406(b)(2) resources and refuge water. Though hydrologic conditions are the primary driver with respect to the availability of water, the reliability of water supplies for water purveyors is dependent on the type of contract and policies for water allocation.

CVP Contracts

CVP water contractors in the Sacramento Valley fall into two categories: Sacramento River Water Rights Settlement Contractors and CVP Water Service Contractors. The contract terms and conditions vary depending on whether a contract is a water right, an agricultural water service, or a municipal/industrial type of contract.

Sacramento River Water Rights Settlement Contractors (SRSC) held water rights in the Sacramento Basin prior to construction of Shasta Dam. The water rights for SRSC exist independent of USBR. Supported by these underlying water rights, the CVP has contracts with SRSC totaling 2.2 maf for the Sacramento River and the San Joaquin River Exchange, and additional contracts totaling 0.9 maf for water right settlement contracts on the San Joaquin River. Contract amounts are supplied in full unless the forecasted Shasta Lake inflow constitutes a "Critical" water year. When Shasta Lake inflow is "Critical," San Joaquin Exchange contractor supplies may be limited to 650,000 acre-feet and Sacramento River and other San Joaquin water rights settlement supplies can be reduced by up to 25 percent (USBR 2004).

CVP Water Service Contractors can face greater cuts depending on water availability. These contractors are agricultural and municipal/industrial (M&I) contractors that have entered into water service contracts for supplemental supplies (project water). These supplies are not based on pre-existing water rights. Water deliveries for this type of contract can be cut up to 100 percent depending on supply, operational requirements, hydrologic conditions, and available reservoir storage.

Cutbacks in water deliveries can be regional or statewide. As an example, water conveyance limitations across the Delta can result in shortage conditions for water contractors located south of the Delta as compared to those located north of the Delta. In 2008 and 2009, Sacramento Valley water service contractors received 100 and 40 percent of their full contract supplies respectively, as opposed to 50 and 10 percent for San Joaquin Valley contractors (Strickland 2011).

Yuba River Development Project

The Yuba River Development Project, FERC 2246, is a water supply, flood control, and power generation project that was put into service in 1970. The project is located in the Yuba River watershed overlying portions of Yuba, Placer, and Sierra Counties.

The project includes New Bullards Bar (dam and storage reservoir), two diversion dams (Our House and Log Cabin), two diversion tunnels (Lohman Ridge and Camptonville, two power tun-nels (New Colgate and Narrows 2), and three powerhouses (New Colgate, New Bullards Bar Minimum Flow Powerhouse, and Narrows 2) for a combined capacity over 395 MW. The Yuba River Development Project (YRDP) does not include Englebright Dam and Reservoir, Daguerre Point Dam, or the Narrows 1 Powerhouse. Narrows 1 Powerhouse is operated by PG&E, FERC 1403.

New Bullards Bar Reservoir has an estimated storage capacity of 966,103 af with a minimum pool of 234,000 af, leaving 732,000 af that can be regulated. Storage capacity of 170,000 af, below full pool is kept available for flood management.

New Bullards Reservoir captures winter and spring runoff and is augmented by diversions from the Middle Yuba River and Oregon Creek. The reservoir is operated to meet minimum carryover storage requirements to ensure that instream flows are met and at least 50 percent of the surface water deliveries are available for the following year as a drought protection measure. In wetter years the reservoir is operated to an EOS target of 650,000 af. Other target levels are set for power generation and flood control operations. The average total inflow to the reservoir is about 1,200,000 af per year, ranging from 163,000 af to 2,800,000 af per year.

Englebright Dam (a USACE facility) was constructed in 1941 as a sediment retention facility. The lake is located downstream from New Bullards Bar at the confluence of Middle Fork and South Fork Yuba Rivers. Narrows 1 (PG&E) and Narrows 2 (YCWA) power plants regulate the flow from Englebright Dam and provide for high flow reservoir releases and increased flood control.

PLACEHOLDER Box SR-4 Lower Yuba River Accord

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Placer County Water Agency Pump Station Project

In March 2008, the Placer County Water Agency (PCWA) Pump Station Project was completed. PCWA was pursuing the development of a year-round water diversion facility capable of diverting up to 35,500 acre-feet annually of PCWA's water entitlements from its Middle Fork Project (MFP) on the American River and the USBR (Reclamation) constructed the facilities to meet PCWA needs.

Prior to 1972, PCWA had installed pumps to lift water supplies to the Auburn Ravine Tunnel for delivery to the PCWA service area. The original pump location interfered with the construction of the Auburn Dam Project (ADP) which started in 1972. USBR installed temporary pumps to lift the supplies, but these had to be removed before the rainy season because of inundation. The ADP construction was abruptly halted after a 1975 earthquake near Oroville which revealed a fault line that traversed the site of the thin arch dam and it soon became apparent the ADP was not to be restarted.

PCWA water supply still had to be addressed. The temporary pumps were problematic for both USBR and PCWA. The annual task of pulling the temporary pumps, re-installing and maintaining them each year was expensive and difficult, they were unreliable and they did not fully meet PCWA's water supply requirements.

In the 1990's PCWA needed greater access to its MFP water to meet its system demands and USBR was under increasing pressure to restore the river. The Pump Station Project would address PCWA's needs, but there were several challenges that had to be faced before USBR and PCWA could move forward with the project. The sudden halt of construction of the Auburn Dam left safety issues such as loose sediment, a coffer dam, and a dangerous diversion tunnel, conditions that had to be addressed before public access or the replacement of the pumps could be accomplished. Rafters and environment and recreation groups were demanding access to the three miles of river that were off limits to the public. The same groups were also concerned with the location of the permanent pump station even though engineering narrowed the possible siting of the station. The possibility of lawsuits continually loomed.

In 2001, USBR, PCWA, and critical local Congressional representatives agreed to "re-water" the half-mile project site and return the three-mile reach of the American River to the public. Work began in September 2003 and now that it is completed it will provide PCWA with the year-round access to its MFP water entitlements from the American River. With the work completed in 2008, PCWA has a secure site, greater and efficient pumping capacity, a restored river and aquatic environment and support from American River advocate groups. The new pumping station also has capacity for expansion for PCWA's additional water rights from the MFP.

Soon or Recently Implemented Projects

Placer County Water Agency Pump Station Project

In March 2008 the Placer County Water Agency Pump Station Project was completed. PCWA was pursuing the development of a year-round water diversion facility capable of diverting up to 35,500 acre-feet annually of PCWA's water entitlements from its Middle Fork Project (MFP) on the American River and the USBR constructed the facilities to meet PCWA needs.

Before the initiation of construction of Auburn Dam, PCWA had built 50-cubic feet per second (cfs) pump station on the North Fork American River to convey PCWA water supplies to the Auburn Ravine Tunnel for delivery to PCWA's service area. However, before PCWA's operations began, Reclamation removed the pump station in 1972 to facilitate construction of Auburn Dam. Reclamation has since installed a seasonal pump station annually as needed by PCWA to meet water supply demands.

Beginning in 1990, PCWA required access to its MFP water annually to meet its system demands under a variety of operating conditions. Reclamation has responded with the seasonal reinstallation and removal of PCWA's original pumps. Due to the location of the installation, the pumps have to be removed before winter each year to prevent damage due to inundation from high river flows. The seasonal pumps did not fully meet PCWA's water supply requirements, were not reliable, and became increasingly expensive to install and maintain. The project purpose included providing PCWA with the year-round access to its MFP water entitlements from the American River.

Freeport Regional Water Facility

The Freeport Regional Water Authority (FRWP) is a cooperative effort of the Sacramento County Water Agency (SCWA) and the East Bay Municipal Utility District (EBMUD) of Oakland to supply surface water from the Sacramento River to customers in central Sacramento County and the East Bay area of California. The diversion point and pumping facilities are located in the South part of Sacramento on the Sacramento River near the small community of Freeport. It provides SCWA with up to 85 million gallons of water per day (mgd) to supplement groundwater use in the central part of the county. EBMUD will use up to 100 mgd of this supply only during dry years, estimated to be three out of every 10 years, as a supplemental water source to complement existing conservation programs.

Construction of the FRWP facilities began in 2007 and became operational in Sacramento in 2011, with the completion of the Vineyard Surface Water Treatment Plant and supplies water to over 40,000 customers.

EBMUD’s facilities were also completed in 2011, but EBMUD will only use FRWP water during dry years. Water from the FRWP will serve 1.3 million customers in Alameda and Contra Costa counties.

Projects Under Consideration, Actively Planned or Under Construction

Sacramento Regional WWTP upgrades to Tertiary The Central Valley Regional Water Quality Control Board has ordered a change in permitting requiring the Sacramento metropolitan area to reduce the amount of ammonia it discharges into the Sacramento River from its wastewater treatment plant.

The Sacramento Regional County Sanitation District was seeking a renewal of its permit to discharge secondary-level treated wastewater from its regional treatment plant near Freeport. The treatment plant, which utilizes several sedimentation processes, chlorination, de-chlorination, and the dilution power of the river, does not remove ammonia from the wastewater stream.

Recent studies suggested that ammonia and other nutrients may be disrupting the food web in the environmentally troubled Delta, contributing to the decline in native fish populations such as Delta smelt.

Effluent from the treatment plant has been identified as the largest single source of ammonia in the Delta watershed. The Sacramento Regional County Sanitation District has said upgrading the treatment plant to remove ammonia would cost approximately $800 million. The district has also said there is not enough scientific evidence to justify requiring the district to remove ammonia.

The draft discharge permit also requires the district to remove pathogens through tertiary filtration and disinfection, which the district estimates would cost an additional $1.3 billion. The draft permit proposes a 10-year timeframe for the district to comply with the new requirements and includes addressing all factors affecting the Delta’s health.

There are concerns the upgrade could double customer rates by the end of construction in 2023. More information can be found online at: http://www.acwa.com/news/delta/draft-permit-could-require-changes-sacramento-regional-wastewater-treatment-plant and http://www.capradio.org/articles/2013/06/24/sacramento-wastewater-treatment-plant-to-upgrade/

Davis-Woodland Planned Diversion

In September 2009, the Cities of Woodland and Davis established the Woodland-Davis Clean Water Agency (WDCWA), a joint powers authority, to implement and oversee a regional surface water supply project.

The regional project will replace deteriorating groundwater supplies with safe, more reliable surface water supplies from the Sacramento River. Once complete, the project will serve more than two-thirds of the urban population of Yolo County, CA. It will also serve UC Davis, a project partner. The project goals are to provide a new water supply to help meet existing and future needs, improve drinking water quality and improve the quality of treated wastewater

The project plans include a jointly-owned and operated intake on the Sacramento River (WDCWA in partnership with RD 2035), raw water pipelines connecting the intake to a new regional water treatment plant, and separate pipelines delivering treated water to Woodland, Davis and UC Davis. Improvements to existing water supply systems will vary for Woodland and Davis and will include facilities such as distribution pipelines, water storage tanks and booster pump stations.

The project will divert up to 45,000 acre-feet of water per year from the Sacramento River. Water rights were granted in March 2011, and will be subject to conditions imposed by the state. Water diversions will be limited during summer and other dry periods. A more senior water right for 10,000 acre feet was purchased from the Conaway Preservation Group to provide summer water supply. Groundwater will continue to be used by Woodland and Davis during when demand for water cannot be met with surface water supplies alone.

The water treatment facility will be constructed to supply up to 30 million gallons of water per day, with an option for future expansion to 34 million gallons per day. Of that amount, Woodland's share of treated surface water will be 18 million gallons per day, with Davis' share at 12 million gallons per day. Approximately 5.1 miles of pipeline will transport "raw" water from the surface water intake on the Sacramento River to the water treatment plant located south of Woodland (see map). From there, the treated water will travel 7.8 miles via pipeline to Davis and up to 1.4 miles to Woodland. http://www.wdcwa.com/the_project

North Bay Aqueduct Alternative Intake

The California Department of Water Resources (DWR) proposes to construct and operate an alternative intake on the Sacramento River, generally upstream of the Sacramento Regional Wastewater Treatment Plant, and connect it to the existing North Bay Aqueduct (NBA) system by a new segment of pipe. The proposed alternative intake would be operated in conjunction with the existing NBA intake at Barker Slough. The North Bay Aqueduct Alternative Intake Project (NBA AIP or proposed project) would be designed to improve water quality and to provide reliable deliveries of State Water Project (SWP) supplies to its North Bay contractors, the Solano County Water Agency (SCWA) and the Napa County Flood Control and Water Conservation District (Napa County FC&WCD).

DWR, the Lead Agency under the California Environmental Quality Act (CEQA), is preparing an Environmental Impact Report (EIR). As part of the public involvement process for the EIR, the lead agencies asked for input on the scope of the NBA AIP EIR through a series of meetings and a written comment period (scoping).

Natomas Mutual Water Company converting irrigation supplies to urban uses

Natomas Central Mutual Water Company controls water rights for use on 55,000 acres of agricultural lands in Northwest Sacramento and Southern Sutter County. Their 120,000 acre feet of water rights are held in 6 licenses, 5 of which allow for irrigation, industrial, municipal and domestic use. Besides its licenses, NCMWC has other permits for winter water from the Sacramento River, drainage water and groundwater facilities.

NCMWC has engaged Golden State Water Company to service 7,500 acres approved by the Sutter County voters for development. Sutter Pointe is a proposed planned community is located approximately 4 miles north of the City of Sacramento. It is Sutter County's largest development and would accommodate 47,000 to 49,000 people over a 20 to 30-year build-out. The plan calls for 17,500 homes, 20,000 jobs, 3,600 acres (1,500 ha) of employment designated uses, and 1,000 acres (400 ha) of community service uses, which includes parks, schools, open space and other community facilities.

Work on infrastructure, such as roads and levees, which will service the development, has been ongoing. However, the Sutter Pointe as a construction project has not yet started, probably due to the area’s economic slowdown. Additional information can be found at: http://www.cpuc.ca.gov/Environment/info/esa/gswc_sp/index.html

The Sacramento River Diversion

This is a joint venture for PCWA and City of Sacramento. Prior to the economic slowdown of 2008, Placer County Water Agency (PCWA) was the lead agency pursuing a new diversion from the Sacramento River. The project is expected to continue, but not at this time.

PCWA has a 35,000 acre-foot water right was established by the Water Forum Agreement of 1997, a formal agreement of water purveyors, environmentalists, agriculturalists, business leaders, along with city and county governments in Sacramento, El Dorado and Placer counties promoting ecosystem preservation along the lower American River. Along with PCWA, the Cities of Sacramento and Roseville, and the Sacramento Suburban Water District have their own allocations from this new diversion and were to take part in funding the project.

The new supplies from the Sacramento River are being planned for the expected growth in the Northern Sacramento, and Western Placer County area. The point of diversion is Natomas Central Mutual Water Company facility several miles upstream from the confluence of the American and Sacramento Rivers. Supplies will be conveyed via pipeline to the treatment facilities within the individual purveyor service areas.

However, with the economic slowdown at the end of the last decade, the project is on hold. The project is the most economical option for PCWA to increase its supplies, so the project will probably be pursued again soon. The City of Sacramento and the other entities are also not pursuing the project at this time.

Addition information can be found at: https://ucmshare.ucmerced.edu/docushare/dsweb/Get/Document-105308/02_exec_summ.pdf

Water Quality

Generally, water quality in the Sacramento Valley is good for both surface water and groundwater; however, an issue getting increased attention is the salinity of surface water and the subsequent salt loading that occurs for south of Delta exporters (CVRWQCB 2011b). Salinity impacts to groundwater are also a concern with respect to municipal wastewater recycling.

Water Boards throughout the State adopt basin plans that layout a framework for how the Board will protect water quality in each region. The basin plans designate the beneficial uses and establish an implementation program to achieve the water quality objectives and protect the beneficial uses. The implementation program describes how the Board will coordinate its regulatory and non-regulatory programs to address specific water quality concerns.

A primary goal of the Board is to develop a comprehensive salt and nitrate management plan for the Central Valley. The long term plan will identify and require discharger implementation of management measures aimed at the reduction and/or control of major sources of salt and nitrate as wells as support activities that alleviate known impairments to drinking water supplies.

Surface Water Quality

Central Valley Salinity

Salinity levels (measured as Electrical Conductivity (EC)) within the Sacramento Hydrologic Region are low compared to other regions of the State. EC levels within upper reaches of the Sacramento River range from 84 - 140 µmhos/cm and gradually increase downstream. Irrigation return flows increase the salinity of the river for most of the year except during spring. Feather River has lower salinity levels than the Sacramento River and dilutes EC below the confluence of the two rivers. Though EC levels are relatively low, the volume of water exported south of the Delta is a concern with respect to the total salt load being exported to those regions. Salt management is considered the most serious long-term water quality issue in the central valley. More salt enters than leaves the San Joaquin River Basin resulting in unavoidable degradation of groundwater. This is a focus of the Central Valley Regional Water Quality Control Board's Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS initiative).

The CV-SALTS initiative will include basin plan amendments that will establish regulatory structure and policies to support basin-wide salt and nitrate management. The regulatory structure will have five key elements:

- Refinement of agricultural supply, municipal and domestic supply, and groundwater recharge estimates
- Revision of water quality objectives for these uses
- Establishment of policies for assessing compliance with the beneficial uses and water quality objectives
- Establishment of management areas where there are large scale differences in baseline water quality, land use, climate conditions, soil characteristics and existing infrastructure and where short and long term salt and/or nitrate management is needed
- Development of an overarching framework to provide consistency for the development of management plans within the management areas.

In a related issue, the goal of the State Water Board Recycled Water Policy is to have a salt/nutrient management plan for every groundwater basin in California to be developed by local stakeholders. The plan is to be adopted by the Regional Water Board into its Basin Plan. Plans are due to the Regional Board by May 2014.

As part of the CVRWQCB triennial review of the Water Quality Control Plan for the Sacramento River, Board staff has started the assessment of municipal and domestic water supply beneficial use relative to the water quality objectives for agricultural water bodies for the Cities of Willows, Colusa, Live Oak, and Biggs (CVRWQCB 2012).

Metals from Mining

Legacy issues associated with historic mining activities continue to be a problem today. Copper, cadmium, zinc, and lead are metals that are naturally found in high concentrations in the “Copper Crescent” in Shasta County. Mining activities increase the amount of metals that enter nearby waterways. Water bodies in the area are impaired due to the elevated levels of copper, cadmium, zinc and lead. These metals are toxic to aquatic life at elevated concentrations although concentrations that are toxic to aquatic life may not be high enough to cause human health impacts.

Copper mining in the Upper Feather River watershed has also caused copper, cadmium and zinc impairments in several of the Upper Feather River tributaries. The largest mine in this area is the Walker Mine, an inactive copper mine about 12 miles east of Quincy in Plumas County. Acidic and metal-laden water (acid mine drainage) discharging from the mine and tailings has long affected the nearby streams of Dolly Creek and Little Grizzly Creek. The discharge was reported to have eliminated aquatic life in Dolly Creek, downstream from its confluence with the mine drainage, and in Little Grizzly Creek downstream from its confluence with Dolly Creek for a distance of approximately ten miles from the mine. Little Grizzly Creek flows to Indian Creek, a tributary to the North Fork of the Feather River.

Inorganic mercury enters waterways when soils erode, atmospheric dust falls to the ground, and mineral springs discharge. Another significant source is cinnabar ore (mercury sulfide) that was mined in the Inner Coast Ranges for elemental mercury (quicksilver). This liquid form of mercury was transported from the Coast Ranges to the Sierra Nevada for gold recovery where several million pounds of mercury were lost to the environment during the gold rush. In various aquatic environments, inorganic mercury can be converted to methylmercury which is a potent neurotoxin. Methylmercury is readily absorbed from water and food, and therefore concentrations multiply greatly between water and top predators of aquatic food chains. The cumulative result of this bioaccumulation is more than a million-fold increase in concentrations of methylmercury in predatory fish such as bass and fish-eating wildlife such as terns and eagles (SRWP 2010).

Many streams and reservoirs in the Sacramento River Hydrologic Region contain fish with elevated concentrations of methyl mercury. Cache Creek is one source that transports mercury from abandoned and orphaned mercury mines in the Coast Range to the Cache Creek Settling Basin and eastward to the Yolo Bypass. Cache Creek accounts for 60 percent of the mercury discharged within the Central Valley (EPA 2012a).

Pesticides

In the last six years, urban storm sewer outfalls draining new development in western Placer County and the City of Sacramento were identified sources of pyrethroid-caused aquatic toxicity (EPA 2012b). In 2011, the California Department of Pesticide Regulation (DPR) issued two sets of draft surface water protection regulations addressing pesticide applications. The first set of regulations prohibits pesticide application within 100 feet from a sensitive aquatic resource and also to saturated soils within 48-hours of a predicted storm event. The regulations require retention of irrigation runoff up to four weeks after application and restrict pesticide application to spot and crack-and-crevice treatment on impervious surfaces (EPA 2012b).

DPR's second set of regulations are intended to reduce pyrethroid pesticide use for outdoor non-agricultural uses. The regulations identify application methods depending on the type of impervious surface being treated (EPA 2012a). The CVRWQCB is addressing pesticide-caused aquatic resource impairments through the Nonpoint Source Program, Irrigated Lands Regulatory Program (ILRP), stormwater permits, TMDLs, and new water quality criteria (EPA 2012a).

The CVRWQCB is developing water quality criteria and related TMDLs for current use pesticides for all waterways in the central valley that support aquatic life. Phase I of this effort includes organophosphate pesticides (diazinon and chlorpyrifos). Phase II will address pyrethroid pesticides and possibly other pesticides of concern (EPA 2012a).

In 2012, the SWRCB issued a draft statewide general stormwater permit for small Municipal Separate Storm Sewer Systems (MS4s) which cover municipalities with a population less than 100,000. The draft permit requires the permittee to evaluated the use of pesticides and reduce pesticide discharges.

PLACEHOLDER Box SR-5 Central Valley Regional Board Irrigated Lands Regulatory Program

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Groundwater Quality

The following contaminants have been found to occur regionally in groundwater:

- Arsenic
- Boron
- Localized contamination by organic compounds and nitrates
- Hexavalent Chromium.

High concentrations of arsenic have been found in wells located towards the center of the Sacramento Valley along the Sacramento and Feather rivers. The source of the arsenic is from minerals dissolved from the volcanic and granitic rocks of the Sierra Nevada Mountains.

Boron has been detected at concentrations greater than the non-regulatory human-health notification levels of 1,000 µg/l in several aquifers located within southern and middle parts of Sacramento Valley. High concentrations of boron found in wells located along Cache and Putah Creeks are likely associated with old marine sediments from the Coast Ranges.

PCE levels exceeding maximum contaminant levels (MCLs) have been detected in a number of water systems in Butte County and Sacramento County. PCE was the main solvent used for dry cleaning. Its occurrence is also associated with textile operations and degreasing operations.

Nitrate levels in public supply wells along the west side of the Sacramento Valley have occasionally exceeded the MCL but most of the concentrations are well within the MCL except for a public water supply system located in Olivehurst. Groundwater in the Chico urban area and the Antelope area of Red Bluff also has high nitrate levels. For the Chico urban area, the Central Valley Water Board has issued a prohibition of discharge from individual disposal systems in the area.

Concentrations of Chromium at levels above the detection limit (above 1 µg/l) have been detected in many active and standby public supply wells along the west or valley floor portion of the valley. Chromium is a metal found in natural deposits of ores containing other elements, mostly as chrome-iron ore. Sampling of drinking water throughout California suggests that hexavalent chromium may occur naturally in groundwater in many locations.

The Central Valley Water Board has developed and approved a groundwater quality protection strategy. The strategy makes recommendations on how to implement existing regulations and to achieve groundwater protection goals. Recommendations from the strategy are the following:

- Development of Salt and Nutrient Management Plan.
- Implement groundwater monitoring program. Monitoring will focus on water quality and waste discharge requirements.
- Implementation of groundwater protection programs through IRWM Plan Groups.
- Broaden public participation in all programs.
- Coordinate with State and local agencies to implement a Well Design and Destruction Program
- Development of a groundwater quality database.
- Establishment of a regulatory process for alternative methods of dairy waste disposal.
- Development of individual and general orders for confined animal feeding operations.
- Implementation of a long-term irrigated lands program. To date, the Board has developed the first set of draft Waste Discharge Requirements under the irrigated lands program.
- Coordination with California Department of Food and Agriculture to identify methods to enhance fertilizer program.
- Reduce site cleanup backlog.
- Draft waiver following new regulations adopted based on AB 885. (AB885 requires the State Water Board to develop regulations or standards for the permitting and operation of specified categories of onsite sewage treatment systems.)
- Update guidelines for waste disposal for land developments.
- Develop methods to reduce the backlog and increase the number of facilities regulated.

PLACEHOLDER Box SR-6 Central Valley Regional Board Water Quality Certification Program

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Drinking Water Quality

The region has an estimated 504 community drinking water systems. The majority (over 80%) of these community drinking water systems are considered small (serving less than 3,300 people) with most small water systems serving less than 500 people (see Table SR-13). Small water systems face unique financial and operational challenges in providing safe drinking water. Given their small customer base, many small water systems cannot develop or access the technical, managerial and financial resources needed to comply with new and existing regulations. These water systems may be geographically isolated, and their staff often lacks the time or expertise to make needed infrastructure repairs; install or operate treatment; or develop comprehensive source water protection plans, financial plans or asset management plans (EPA 2012).

PLACEHOLDER Table SR-13 Summary of Large, Medium, Small, and Very Small Community Drinking Water Systems

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Medium and large water systems account for less than 20% of region's drinking water systems; however these systems deliver drinking water to over 90% of the region's population (see Table SR-14). These water systems generally have financial resources to hire staff to oversee daily operations and maintenance needs, and hire staff to plan for future infrastructure replacement and capital improvements. This helps to ensure that existing and future drinking water standards can be met.

In general, drinking water systems in the region deliver water to their customers that meet federal and state drinking water standards. Recently the Water Boards completed a draft statewide assessment of community water systems that rely on contaminated groundwater. This draft report identified 61 community drinking water systems in the region that rely on at least one contaminated groundwater well as a source of supply (See Table SR-15). Arsenic is the most prevalent groundwater contaminant affecting 73 community drinking water wells in the region. A number of community drinking water wells are also affected by nitrate and tetrachloroethylene (PCE) contamination (see Table SR-15). The majority of the affected systems are small water systems which often need financial assistance to construct a water treatment plant or alternate solution to meet drinking water standards.

PLACEHOLDER Table SR-14 Summary of Small, Medium, and Large Community Drinking Water Systems in the Sacramento River Hydrologic Region that Rely on One or More Contaminated Groundwater Well(s)

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PLACEHOLDER Table SR-15 Summary of Contaminants Affecting Community Drinking Water Systems in the Sacramento River Hydrologic Region

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Land Subsidence

In the Sacramento River Hydrologic Region, land subsidence associated with groundwater withdrawal has been documented in the North American and Yolo Subbasins. As noted previously, DWR's Sacramento Valley subsidence monitoring network includes 11 extensometers and a GPS network. Some extensometers show land subsidence while others show a net land expansion due to wetting of clays. Eight of the 11 extensometers that DWR operates in the Sacramento Valley show no inelastic subsidence, although they do show elastic subsidence on the order of 0.03 foot. The other three extensometers show no elastic subsidence.

The Zamora area within Yolo County portion of the Colusa Subbasin has experienced land subsidence due to groundwater pumping. Leveling surveys from 1950 to 1990 indicate that more than four feet of subsidence has occurred midway between Knights Landing and Zamora. The Zamora extensometer-11N01E24Q008M, the oldest extensometer in the area (see Figure SR-15A), was installed to monitor subsidence (Blodgett et al. 1990). This extensometer has one of the longest histories of data, going back to 1992. The data show a total land displacement over one foot, with an average subsidence of -0.05 feet per year. The associated well data from the deep aquifer zone show an average decline in groundwater levels of -0.2 feet per year. The Yolo County Flood Control and Water Conservation District (YCFCWCD) published a Groundwater Management Plan in 2006 which covers Yolo County portion of the Colusa Subbasin. One of the groundwater management plan's goals is to "maintain or enhance local groundwater quantity and quality, resulting in a reliable groundwater supply for beneficial uses and avoidance of adverse subsidence." The plan includes basin management objectives (BMOs) that address the problem of land subsidence resulting from groundwater pumping. The BMOs have both a trigger and a response; the trigger occurs when monitoring data show that a certain condition has been reached, and the response is the action to address the condition (YCFCWCD 2006). This type of action plan is a good model to follow when managing water resources in an area prone to land subsidence. By maintaining a long-term balance of groundwater production and recharge, the negative effects of land subsidence can be minimized.

Although some land subsidence is occurring in the southern portion of the Sacramento Valley, the central and northern portions of the valley have not yet recorded any inelastic land subsidence. Figure SR-15B shows time-graph of extensometer 17N02W09H002M established in 2005 and located northwest of Colusa, in the Colusa Subbasin near the center of the Sacramento Valley. Data indicate that groundwater levels from the deep aquifer zone are declining at a rate of about -0.8 feet per year while land subsidence has not yet been observed.

Figure SR-15B shows time-graph of extensometer 22N02W15C002M which is the most northern extensometer site within the Sacramento Valley, located in the Corning Subbasin between Orland and Hamilton City. Data indicate that groundwater levels in the deep aquifer zone are declining at an average rate of -3.0 feet per year, while land is showing a slight expansion of +0.01 feet per year. This may be due to clay layers that are becoming more saturated due to an increase in applied irrigation water. The expansion of clay could be masking any land subsidence that may be occurring.

As groundwater pumping in the Sacramento Valley increases, the potential for land subsidence also increases. Although there is an existing land subsidence network in place, additional extensometers are needed for assembling a complete land subsidence monitoring grid. Two areas that show data gaps from the lack of extensometers are the areas south of the Sutter Buttes and the area near Red Bluff. These areas are expanding in agriculture and groundwater is being extracted at an increasing rate. Additional subsidence monitoring is needed in these areas to monitor the aquifers for potential subsidence. The GPS network constructed in 2008 unfortunately has not yet been resurveyed; therefore, no results from that effort could be reported.

PLACEHOLDER Figure SR-15 Selected Subsidence and Groundwater Level Hydrographs for the Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Groundwater Conditions and Issues

Groundwater Occurrence and Movement

Aquifer conditions and groundwater levels change in response to varying supply, demand, and climate conditions. During dry years or periods of increased groundwater extraction, seasonal groundwater levels tend to fluctuate more widely and, depending on annual recharge conditions, may result in a long-term decline in groundwater levels, both locally and regionally. Depending on the amount, timing, and duration of groundwater level decline, nearby well owners may need to deepen wells or lower pumps to regain access to groundwater.

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

During years of normal or above normal precipitation, or during periods of low groundwater extraction, aquifer systems tend to recharge and respond with rising groundwater levels. As groundwater levels rise, they reconnect to surface water systems, contributing to surface water base flow or wetlands, seeps, and springs. The Sacramento Valley Groundwater Basin has historically been considered a groundwater rich area. Major surface water systems such as the Sacramento, Feather, Yuba, Bear, and American rivers provide significant recharge to regional aquifers, and serve as an important source of surface water supply for agricultural, urban, and managed wetland uses. In addition, numerous smaller creeks along the eastern edge of the valley provide source of local aquifer recharge. Reduced precipitation along the west side of the valley results in mostly ephemeral creeks; however, these surface water systems also provide an important source of groundwater recharge.

The movement of groundwater is from areas of higher hydraulic potential to areas of lower hydraulic potential, typically from higher elevations to lower elevations. Under predevelopment conditions, the occurrence and movement of groundwater in the region 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. However, under agricultural and urban development pressures, increasing groundwater extractions may have influenced the natural occurrence and movement of groundwater on a seasonal and, in some areas, on an ongoing basis. Groundwater extraction over portions of western Glenn, southern Tehama, Butte (between Chico and Durham), southern Colusa, Yolo, Solano, and Sacramento Counties have created a patchwork of groundwater table depressions that serve to redirect and capture groundwater flow that may otherwise have contributed to nearby surface water systems. Deviation from natural groundwater flow conditions is also influenced by thousands of large production wells screened over multiple aquifer zones, creating a conduit for vertical aquifer mixing. In areas providing surface water for agricultural use, infiltration along miles of unlined water conveyance canals and percolation of applied irrigation water can also influence groundwater movement by creating significant areas of groundwater recharge where none previously existed.

Depth to Groundwater

The depth to groundwater has a direct bearing on the costs associated with well installation and groundwater extraction operations. Understanding the local depth to groundwater can also provide a better understanding of the local interaction between the groundwater table and the surface water systems, and the contribution of groundwater aquifers to the local ecosystem.

Figure SR-16 is a spring 2010 depth to groundwater contour map for the Sacramento Valley and Redding Area Groundwater Basins. Groundwater contour maps were developed using groundwater level data that is available online from DWR's Water Data Library (http://www.water.ca.gov/waterdatalibrary/) and CASGEM system (http://www.water.ca.gov/groundwater/casgem/). The contour lines in the figure represent areas having similar spring 2010 depth to groundwater values. Precipitation for water year 2010 was 96 percent of the previous 30-year average; however, precipitation for the preceding three years averaged about 71 percent of average. Contour lines were developed for only those areas having sufficient groundwater level data and for only those aquifers characterized by unconfined to semi-confined groundwater conditions. Most of the areas with limited groundwater data fall within the Redding Area Groundwater Basin, the northwestern portion of the Sacramento Valley Groundwater Basin, and the Delta region in the southernmost portion of the Sacramento River Hydrologic Region. Depth to groundwater contour map was not developed for groundwater basins outside the Central Valley. Information regarding depth to water in these basins may be obtained online through DWRs Water Data Library (http://www.water.ca.gov/waterdatalibrary/).

PLACEHOLDER Figure SR-16 Spring 2010 Depth to Groundwater Contours for the Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Figure SR-16 shows that one third of the Redding Area Groundwater Basin is characterized by a spring 2010 depth to groundwater of about 40 to 60 feet below ground surface. The areas of shallower ground water typically occur over the center of the basin and adjacent to major surface water systems. Groundwater recharge associated with coarse-grained deposits along perennial streams and unlined agricultural distribution systems contributes to groundwater levels of less than 20 feet below ground surface in many smaller localized areas. Towards the edges of the basin, as the ground surface elevation increases, the depth to groundwater quickly increases to over 100 feet below ground surface, reaching a maximum of about 200 feet below ground surface near the southern most end of the basin

Figure SR-16 shows that in the Sacramento Valley Groundwater Basin the spring 2010 depth to water is highly variable, ranging from a low of 10 feet below ground surface in areas adjacent to the Sacramento and Feather Rivers, to a maximum of about 160 feet below ground surface n the North American

Subbasin between Sacramento and Roseville. About half of the Sacramento Valley Groundwater Basin is characterized by spring 2010 groundwater levels that are less than or equal to 20 feet below ground surface. Much of the shallow groundwater occurs in areas surrounding the Sutter Buttes where surface water is applied for rice production, and southward along the axis of the valley adjacent to the Sacramento River. Shallow groundwater table adjacent to surface water systems is indicative of interconnected surface water and groundwater systems.

Along the west side of the Sacramento Valley Groundwater Basin, adjacent to Interstate 5 between Williams and Zamora, the depth to groundwater is greater than in areas closer to the Sacramento River. This is likely due to a higher reliance on groundwater supplies for these areas, combined with relatively low recharge along the east-facing slope of the Coast Ranges. Local trends of increased depth to groundwater are also seen near the cities of Woodland and Davis, which rely entirely on groundwater for municipal water supplies. Smaller areas of increasing depth to groundwater trends also exist along the west side of Glenn County, near Chico, and south of Chico near Durham; however, the spring 2010 depth to groundwater map data for these areas are somewhat limited.

Groundwater Elevations

Groundwater elevation contours can help estimate the direction of groundwater movement and the gradient, or rate, of groundwater flow. Figure SR-17 is a spring 2010 groundwater elevation contour map for the Sacramento Valley and Redding Area Groundwater Basins. Contour lines shown are generally indicative of the unconfined portion of the aquifer system and approximate the elevation of the groundwater table. Groundwater movement direction is shown as a series of arrows along the groundwater flow path; these flow direction arrows do not provide information regarding vertical flow within the aquifer system. Similar to the spring 2010 depth to groundwater contours, groundwater elevation contours were developed for only those areas having sufficient groundwater level data and for only those aquifers characterized by unconfined to semi-confined aquifer conditions. Groundwater elevation contours were not developed for groundwater basins outside the Central Valley.

Figure SR-17 shows that in the Redding Area Groundwater Basin the spring 2010 groundwater elevations range from a low of about 390 feet above mean sea level adjacent to the Sacramento River, to a high of about 590 feet above mean sea level in the northwestern foothill portions of the basin. In the northern Sacramento Valley, the regional groundwater movement follows a relatively natural flow path from the edges of the basin to the Sacramento River and nearby drainages. The groundwater flow gradient remains relatively flat along the Sacramento River and the center axes of the basin, where topographic relief is low. The groundwater flow gradients increase rapidly at the edges of the basin as the topographic relief increases. Lack of groundwater monitoring in the South Battle Creek Subbasin and limited data in the Millville, Rosewood and Bowman Subbasins rule out additional analysis in these areas. Additional information for the Redding Area Groundwater Basin indicates a strong connection between surface water and groundwater systems along the center of the basin, and a significant contribution from the shallow aquifer systems to the base flow of nearby streams and rivers.

Figure SR-17 also shows that for the Sacramento Valley Groundwater Basin, groundwater elevations range from below sea level near the Sacramento-San Joaquin Delta and in portions of the North and South American Subbasins, to over 300 feet above mean sea level along western and northern portions of the basin. Spring 2010 groundwater elevation contours for the majority of the groundwater basin generally follow the valley topography, with groundwater flowing from the edges of the basin towards the

Sacramento and Feather Rivers and then southward along the valley axis. From Red Bluff to Colusa, the spring 2010 groundwater flow indicates the Sacramento River to be a gaining stream and the main corridor of groundwater discharge in the valley. Between Colusa and Knights Landing, the pattern of groundwater flow begins to change, indicating a transition whereby the Sacramento River begins to serve as a major source of recharge to the local aquifer systems. A series of depressions is observed in the North and South American Subbasins that are likely the result of groundwater development for urban use in Sacramento and Davis areas. These radiating depressions in the groundwater table tend to induce infiltration from overlying surface water systems and capture adjacent groundwater underflow that may otherwise have discharged to nearby surface water systems, and contributed towards their base flow. A smaller groundwater depression and distortion of the natural pattern of groundwater flow occurs around the city of Woodland and to the adjacent areas towards the north. The depression in this area is likely caused by groundwater extraction for urban, agricultural and industrial uses. By diverting and capturing the surrounding groundwater flow, these series of groundwater depressions can reduce amount of surface flow in streams.

Figure SR-17 illustrates several radiating patterns of groundwater recharge associated with key Sacramento Valley surface water systems. Key areas of spring recharge include the Stony Creek, between the Corning and Colusa Subbasins; the Thermalito Afterbay, near where the Feather River enters the Sacramento Valley Groundwater Basin; the Yuba River, adjacent to the North and South Yuba Subbasins divide; the Bear River, along the northern border of the North American Subbasin; Cache Creek as it exits the Capay Valley west of Woodland; and Putah Creek near Winters.

The topographic low point of the Sacramento River region includes the Sacramento-San Joaquin Delta in southernmost portion of the valley. This area has limited groundwater level data; however, existing data indicates that delta groundwater elevations are generally at or slightly below sea level.

The springtime groundwater levels typically represent the highest groundwater levels of the year and a time when annual groundwater extractions are at a minimum and aquifer recharge is at the annual maximum. Additional comparison of the spring versus summer or fall groundwater levels is highly recommended in order to more fully understand seasonal variations of groundwater occurrence and movement and how these variations are affected by changes in annual precipitation, surface water deliveries, and demand. Summer groundwater elevation contours developed by DWR for the northern portion of the Sacramento Valley Groundwater Basin indicate that large reaches of the Sacramento River appear to be gaining flow during the spring months due to shallow groundwater discharge to the river, typically giving away to loosing reaches of the river (discharging surface water to adjacent aquifer systems) during the summer months that extend all the way north to Red Bluff.

PLACEHOLDER Figure SR-17 Spring 2010 Groundwater Elevation Contours for the Sacramento River Hydrologic Region

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Groundwater Level Trends

Plots of depth-to-water measurements in wells over time (groundwater level hydrographs) allow analysis of seasonal and long-term groundwater level variability and trend over time. Because of the highly variable nature of the physical aquifer systems within each groundwater basin, and because of the variable nature of annual groundwater availability, recharge, and surrounding land use practices, the hydrographs presented herein do not attempt to illustrate or depict average aquifer conditions over a broader region. Rather, the selected hydrographs are intended to help tell a story about how the local aquifer systems respond to changing groundwater pumping quantity and to the implementation of resource management practices. The hydrographs are designated according to the State Well Number System (SWN), which identifies each well by its location using the public lands survey system of township, range, section, and tract.

Hydrograph 38N07E23E001M

Hydrograph 38N07E23E001M (Figure SR-18A) is from a domestic well located in the Big Valley Groundwater Basin in the upper portion of the Sacramento River Hydrologic Region. The Big Valley area is a rural cattle ranching and hay cropping area largely dependent on groundwater for irrigation during dry years. The well is constructed in the unconfined upper aquifer system. The area surrounding the well is a small residential community. The hydrograph shows seasonal fluctuations in shallow aquifer groundwater levels of about five to eight feet during years of average hydrology, and approximately 15 to 20 feet during drought periods. A long-term comparison of spring-to-spring groundwater levels shows a gradual decline and recovery of groundwater levels associated with the 1987-93 drought and a partial recovery from the 2001 drought. Since 2000, spring-to-spring groundwater levels show a fairly steady trend of declining groundwater levels even during years of average hydrology and an increase in the seasonal groundwater level fluctuations due to increased groundwater pumping. Although the average groundwater level decline since 2000 is one-foot per year, the declines indicate that the annual rate of groundwater extraction are outpacing aquifer recharge. The hydrograph does indicate some aquifer recovery associated with above average precipitation during the 2010-11 water years. The Big Valley Groundwater Basin is designated a CASGEM medium priority basin.

Hydrograph 24N02W24D002-4M

Hydrograph 24N02W24D002-4M (Figure SR-18B) is from a multi-completion well located in Tehama County within the northern portion of the Vina Subbasin near the Sacramento River. The land use is idle or pastures to the east and predominantly orchards to the west. The wells monitor three discrete aquifer zones with screened depths from 346 feet to 989 feet below ground surface. The hydrograph shows the different groundwater levels reflective of each zone with a spread of 7-8 feet between the shallow and the deep zones. The groundwater levels in each aquifer zone generally follow the same seasonal trends of low groundwater levels during the summer and fall, and high groundwater levels during the winter and spring. However, the shallow well hydrograph displays obvious downward spikes due to impacts from nearby pumping indicating that the nearby pumping is extracting groundwater from the same zone that the shallow well is screened in. The intermediate and deep hydrographs slightly mimic the spikes in the shallow zone hydrograph indicating that they are also affected by nearby groundwater extraction, but to a somewhat lesser and more muted degree. The overall 2006 to 2010 groundwater level trend in each zone of this multi-completion well is a decline of approximately one foot. Vina Subbasin is designated a CASGEM high priority basin.

Hydrograph 23N03W13C003-7M

Hydrograph 23N03W13C003-7M (Figure SR-18C) is from a multi-completion well located in the Corning Subbasin of the Sacramento Valley Groundwater Basin, within Tehama County near its southern border. The land use in the surrounding area is mixed with small orchards, pastures, idle, rural communities that all rely on groundwater as primary water source. The wells monitor five discrete aquifer zones with screened depths from 19 feet to 980 feet below ground surface. The hydrograph shows the groundwater levels associated with each of the five aquifer zones, with a range of about 50 feet between the shallowest and the deepest zones. The shallowest well monitors groundwater from the shallowest aquifer zone, which is in direct communication with nearby surface water systems. Water levels in the well respond rapidly to changes in percolation associated with precipitation, applied irrigation water, and nearby surface water systems. The intermediate and deep zones are increasingly separated from surface recharge sources and show an increasingly muted and delayed response to seasonal fluctuations associated with winter recharge and summer extraction. In addition, the intermediate well hydrographs (23N03W13C005-006M) show a change in the vertical gradients between these two aquifer zones during the year. During spring and fall, the deeper of the two wells, 23N03W13C005M, has a lower groundwater level than well 23N03W13C006M indicating there is a downward gradient. During the fall and winter the opposite is true; the groundwater level in well 23N03W13C005M is higher than 23N03W13C006 resulting in an upward gradient to groundwater flow. The change in gradient is probably due to additional groundwater pumping from the deeper aquifer during the spring-summer irrigation season. The two deep well hydrographs mimic each other at almost the same identical groundwater level and fluctuate about 10 feet seasonally, with no obvious impacts from groundwater pumping. The general trend of the two shallowest zones in this multi-completion well from 2007 to 2010 is no net increase or decrease in groundwater levels while the intermediate and deep zones show a downward trend of -0.4 feet to -1.3 feet, respectively. The Corning Subbasin is designated as a CASGEM medium priority basin.

Hydrograph 21N03W33A004M

Hydrograph 21N03W33A004M (Figure SR-18D) is from an irrigation well located in the Colusa County portion of the Colusa Subbasin. The Colusa Subbasin consists of mostly agriculture, pastures, and idle land; there are also several small urban centers. The well is located in the center of the upper portion of the subbasin, midway between the cities of Orland and Willows. The well is 750 feet deep and is constructed in the semi-confined to confined portions of the aquifer system. The land use in the area of the well is predominately agriculture. The hydrograph shows a decline in groundwater levels during the 1970's, prior to bringing in surface water through the Tehama-Colusa Canal. During the 1980's groundwater levels recover due to the combination of switching from groundwater to surface water supply and because of the wet hydrology associated with the 1982 – 1984 water years. The decline in groundwater levels in the early 1990's is likely due to increased surface water price combined with drought conditions, causing many farmers to switch back to groundwater supply. The most recent decrease in groundwater levels in the early 2000s, is likely due to the recent trend of converting pasture, annual crops, and idle land to permanent orchard crops irrigated with groundwater. The hydrograph also shows that the seasonal fluctuation in groundwater levels can be as much as 70 feet over the period of record beginning in 1965. The lowest groundwater levels were during the drought in the late 1970s. Since 2009, the trend of declining groundwater levels has continued and similar to many wells along the west side of the Sacramento Valley, groundwater levels are either at or approaching an all-time low. The overall trend of groundwater levels in this well, based on its entire period of record, is no net increase or decrease. Colusa Subbasin is designated a CASGEM medium priority basin.

Hydrograph 22N01E28J003M

Hydrograph 22N01E28J003M (Figure SR-18E) is from an observation well located in Vina Subbasin along the western edge of Chico and southern edge of the subbasin; the well is influenced by use of groundwater for urban use to the east and for agricultural use to the west. The Vina Subbasin consists of agriculture, pastures, and a portion of a large urban center. The well is constructed in the semi-confined portion of the aquifer system. The local land use immediate to this well is almost 100 percent reliance on groundwater for urban and agricultural uses. The hydrograph shows seasonal fluctuations in groundwater levels of about 15 feet during years of average hydrology and up to 20 feet during drought periods. A long-term comparison of spring-to-spring groundwater levels shows a gradual decline and recovery of groundwater levels associated with the 1975-77 and 1986-94 droughts, and partial recovery associated with the 2001 drought. The hydrograph also show groundwater levels recovering from the 2007-2009 drought period due to an above average water year during 2010-2011. During years of average precipitation, spring-to-spring groundwater levels in this portion of the aquifer system show a trend of slightly declining groundwater levels since the mid-1980s, indicating that groundwater withdrawal is outpacing groundwater recharge. Vina Subbasin is designated a CASGEM high priority basin.

<u>Hydrograph 14N01E14G001M</u>

Hydrograph 14N01E14G001M (Figure SR-18F) is from a well located southwest of the Sutter Buttes in the Sutter Subbasin, less than 0.5 miles east of the Sacramento River. The surrounding land use is dominated by agricultural rice production that uses predominantly surface water. As exhibited by the hydrograph, some areas within the Sacramento River Hydrologic Region are characterized by very little seasonal and long term groundwater level changes. Seasonal groundwater level measurements since 1953 show a very stable water table with a seasonal fluctuation of generally less than 10 feet. The Sutter Subbasin is designated a CASGEM medium priority basin.

<u>Hydrograph 15N04E28D001M</u>

Hydrograph 15N04E28D001M (Figure SR-18G) is from an irrigation well located in the South Yuba Subbasin of the Sacramento Valley Groundwater Basin, near the town of Linda in Yuba County. The hydrograph presents a typical groundwater response for an in-lieu groundwater recharge operation, while also reflecting seasonal fluctuations and long-term water level trends from a rural well. The well is completed to a depth of 210 feet. Prior to approximately 1983, groundwater was the primary water source that was used for irrigation and other purposes in the South Yuba subbasin, which over time created a widespread cone of depression within the aquifer. The depth to groundwater at this location increased from approximately 30 feet below the ground surface in 1947 to almost 85 feet in 1977, a decline of almost 2 feet per year. In 1983, surface water for irrigation was introduced into the South Yuba subbasin by the Yuba County Water Agency and groundwater levels began to recover to its historic high of 25 feet below ground surface in 2008, an increase of almost 2 feet per year. Throughout the period of record, the seasonal fluctuation of groundwater levels was generally within +/- 10 feet. The South Yuba Subbasin is designated a CASGEM medium priority basin.

<u>Hydrograph 10N01W06D001M</u>

Hydrograph 10N01W06D001M (Figure SR-18H) is from an irrigation well located in the Colusa Subbasin in Yolo County along the western boundary of the Sacramento Valley and approximately 2 miles north of Cache Creek. The hydrograph shows the impact of drought conditions on groundwater elevations in an irrigation well completed to a total depth of 223 feet. Prior to the 1976-1977 drought, groundwater elevations seasonally fluctuated from 20 to 30 feet but were generally stable from year to year. However, between 1975 and 1977, the depth to groundwater declined from approximately 60 feet below ground surface in 1975 to 135 feet below ground surface in 1977. The hydrograph also shows the effects of wet years in the early 1980s that followed the dry years of the late 1970s. The effect of the drought on groundwater elevations in this well appears to have been eliminated by 1980; the historical high groundwater elevation occurred in 1983. The drought conditions of the early 1990s as well as in 2009are also reflected in the hydrograph. The Colusa Subbasin is designated a CASGEM medium priority basin.

Hydrograph 07N06E08H001M

Hydrograph 07N06E08H001M (Figure SR-18I) is from a domestic well located in the South American Subbasin in the central portion of rural Sacramento County. The well is completed to a depth of 225 feet. The hydrograph shows a consistent groundwater level decline of almost 60 feet from approximately 1950 until around 1980. From 1980 through 2010, the depth to groundwater has been relatively stable, with a seasonal fluctuation of ± 10 feet or less. The hydrograph is consistent with hydrographs from other nearby wells in the Zone 40 portion of Sacramento County. Prior to the 1980s, groundwater levels declined due to the intensive use of groundwater, which was the primary, if not only, source of water in the area for domestic and agricultural purposes. Although development in the area continued to occur, the stabilization of the groundwater levels are attributed to the higher use of surface water supplies that became available to residential developments, and the fallowing of agricultural areas as they transitioned into new developments in accordance with the County's General Plan. In this case, groundwater levels have not recovered to 1950 levels because groundwater is continuing to be used for domestic and agricultural purposes; however, as shown by the stable hydrograph, groundwater and surface water supplies appear to be used in a balanced way in accordance with the objectives of the area's Groundwater Management Plan. The South American Subbasin is designated a CASGEM high priority basin.

Hydrograph 06N01W24N001M

Hydrograph 06N01W24N001M (Figure SR-18J) is from an unused well located in the Solano Subbasin, within the southernmost portion of the Sacramento Valley Groundwater Basin and also within the northern portion of the Sacramento-San Joaquin River Delta near the City of Vacaville. The well is completed to a depth of 198 feet. Although the records for this well between 1953 and 1963 are incomplete, the groundwater level data after 1963 show a groundwater table recovery from more than 50 feet below the ground surface to levels 10 feet or less below the ground surface by 1975, with groundwater levels at or just below the ground surface occurring numerous times through 2010. Groundwater levels recovered due to the introduction of surface water supplies to the area. In 1959, the City of Vacaville began receiving Solano Project water through an agreement with the Solano County Water Agency. Prior to completion of the Solano Project, which stores surface water in Lake Berryessa constructed in 1957, all water supplies for municipal and irrigation uses were from local groundwater. Prior to 1959, the groundwater levels were declining at a rate of approximately five feet per year, and likely reached depths far greater than the historical low of more than 60 feet below ground surface observed in 1953. The Solano Subbasin is designated a CASGEM medium priority basin.

PLACEHOLDER Figure SR-18 Groundwater Level Trends in Selected Wells in the Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Change in Groundwater Storage

Change in groundwater storage is the difference in stored groundwater volume between two time periods. Examining the annual change in groundwater storage over a series of years helps identify the aquifer response to changes in climate, land use, or groundwater management over time. If the change in storage is negligible over a period represented by average hydrologic and land use conditions, the basin is considered to be in equilibrium under the existing water use scenario and current management practices. However, declining storage over a period characterized by average hydrologic and land use conditions does not necessarily mean that the basin is being managed unsustainably or subject to conditions of overdraft. Utilization 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 conjunctive water management.

Additional information regarding the risks and benefits of conjunctive management can be found online from Update 2013, Volume 3, Chapter 9, the article "Conjunctive Management and Groundwater Storage Resource Management Strategy."

Annual and cumulative change in groundwater storage for the Redding Area and Sacramento Valley Groundwater Basins was calculated between 2005 and 2010 using spring groundwater elevation data, a range of specific yield values for the aquifer, and a Geographic Information Systems (GIS) analytical tool. Groundwater level data from the spring 2005 was used instead of 2006 because the hydrology for 2005 more closely approximated long term average conditions than that of 2006. Beginning the change in storage calculation in 2005, approximately an average water year, yields a more realistic assessment of the annual and cumulative change in storage values in subsequent years.

Based on published literature, minimum and maximum specific yield (Sy) values of 0.07 and 0.17 were determined to be a good approximation of the range of regional aquifer storage parameters. For depth to water and groundwater elevation contour maps discussed previously, groundwater basins having insufficient data to contour and compare year-to-year changes in groundwater elevations were identified as "non-reporting" areas. Change in storage was also not estimated for these "non-reporting" areas.

Spring 2005 to Spring 2010 Change in Aquifer Storage

Figure SR-19 shows an overall decline in groundwater levels for much of the region from 2005 to 2010. Localized groundwater level declines from 20 to 30 feet are seen in the northwestern portion of the Sacramento Valley Groundwater Basin. Localized groundwater level declines from to 10 to 20 feet are seen in the northern, mid- to south-western, and southeastern portions of the Sacramento Valley Groundwater Basin. In rest of the Sacramento Valley Groundwater Basin and Redding Area Groundwater Basin, groundwater level declines from zero to 10 feet are observed.

Table SR-16 and Figure SR-20 show that the average annual change in groundwater elevation and related change in groundwater storage generally follow the annual precipitation or water year type. Only about 50 percent of the Redding Area Groundwater Basin is reportable due to limited monitoring well coverage (Table SR-16A and Figure SR-20A). In contrast, about 65 percent of the Sacramento Valley Groundwater Basin is reportable (Table SR-16B and Figure SR-20B). This is because overall density of groundwater level monitoring within the high groundwater pumping area of the Sacramento Valley Groundwater Basin appears to be good. Much of the non-reportable areas include the western portions of the Red Bluff and Corning Subbasins, and the Delta region where there is limited groundwater use.

As Table SR-16A and Figure SR-20A show, the spring 2005 – spring 2010 cumulative groundwater level decline over the Redding Area Groundwater Basin is estimated to be slightly over three quarters of a foot with corresponding changes in storage. For example, the single year maximum increase in groundwater storage occurred during the 2005-2006 period and ranged between approximately 36 and 88 taf. The maximum single year decline in groundwater storage occurred during the 2006-2007 period and ranged between 32 taf and 78 taf. The cumulative change in groundwater storage over the 2005-2010 period is estimated between approximately 9 taf and 23 taf; the majority of the storage loss occurred in the Anderson Subbasin.

As Table SR-16B and Figure SR-20B show, the annual variability in groundwater storage change for the Sacramento Valley Groundwater Basin is large. The spring 2005 – spring 2010 cumulative groundwater level decline over the basin is estimated to be over three feet with corresponding changes in storage. For example, the single year maximum increase in groundwater storage occurred during the 2005-2006 period and ranged between approximately 0.5 maf and 1.2 maf. The maximum single year decline in groundwater storage occurred during the 2006-2007 period and ranged between 0.9 maf and 2.3 maf. The 2006-2007 decline in groundwater storage is estimated to be between approximately 34 and 82 percent of the average annual groundwater extraction for the entire Sacramento River Hydrologic Region (see Table SR-8). The cumulative change in groundwater storage over the 2005-2010 period is estimated between approximately 0.7 maf and 1.7 mf; these numbers represent between approximately 25 and 60 percent of the average annual groundwater extraction for the region. The large annual variation in groundwater storage changes points to high reliance on groundwater in the Sacramento Valley.

PLACEHOLDER Figure SR-19 Spring 2005 – Spring 2010 Change in Groundwater Elevation Contour Map for the Sacramento River Hydrologic Region

PLACEHOLDER Table SR-16 Spring 2005- Spring 2010 Annual Change in Groundwater Storage for the Sacramento River Hydrologic Region

PLACEHOLDER Figure SR-20 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Sacramento River Hydrologic Region

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Additional information regarding the methods and assumptions for calculating change in groundwater storage is available online from Update 2013, Volume 4, Reference Guide, the article "California's Groundwater Update 2013."

Flood Management

Risk Characterization

Major floods are common in the Sacramento River Hydrologic Region. Slow rise flooding would be nearly the exclusive cause of floods, but many miles of old and new levees, the older ones often raised by using materials at hand, has resulted in a high incidence of structure failure floods. Coastal flooding, caused by inundation due to water-level rise, occurs in the Delta and at Clear Lake. Some of the least substantial levees are in the Delta, where they are subject to continuous waterside inundation. Delta floods have been listed as coastal when levee failure is not a contributor, and as structure failures when levees breach. Flood damage has been observed in the Sacramento River Hydrologic Region since at least 1805. Since the era of building levees began, floods have become less frequent and more damaging. Figures SR-21 and SR-22 provide statistics on the region's exposure to the 100-year and 500-year floodplains.

PLACEHOLDER Figure SR-21 Flood Hazard Exposure to the 100-Year Floodplain, Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

PLACEHOLDER Figure SR-22 Flood Hazard Exposure to the 500-Year Floodplain, Sacramento River Hydrologic Region

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Damage Reduction Measures

Traditionally, the approach to flood management has been to alter or confine natural watercourses to reduce the chance of flooding, minimizing damage to lives and property. This approach looked at floodwaters primarily as a potential risk to be mitigated. Much of the Central Valley now derives its flood protection from the State Plan of Flood Control (SPFC). The SPFC refers to the facilities, lands, programs, conditions, and mode of O&M for the State/federal flood protection system.

The SPFC system includes the following major facilities:

- About 440 miles of river, canal, and stream channels (including an enlarged channel of the Sacramento River from Cache Slough to Collinsville)
- About 1,000 miles of levees (along the Sacramento River channel, Sutter and Yolo basins, and Feather, Yuba, Bear, and American rivers)
- Four relief bypasses (Sutter, Tisdale, Sacramento, and Yolo bypasses)
- Knights Landing Ridge Cut to connect the Colusa Basin to the Yolo Bypass
- Five major weirs (Sacramento Weir, Fremont Weir, and Moulton, Tisdale, and Colusa weirs)
- Two sets of outfall gates
- Five major drainage pumping plants (CDWR 2012)

These facilities were constructed as part of several large flood control projects:

- Sacramento River Flood Control Project
- Sacramento River and Major and Minor Tributaries Project
- Sacramento River Bank Protection Project
- American River Flood Control Project
- Sacramento River Project, Chico Landing to Red Bluff
- Middle Creek Project
- North Fork Feather River Project

The Sacramento River Flood Control Project (SRFCP) is an umbrella term for six large USACE projects that, together with six reservoirs on the major rivers, constitute the State’s largest flood management system. The SRFCP includes levees, bypasses, weirs, a debris basin, and appurtenant facilities. It extends from Elder Creek in Tehama County downstream to the Delta, a distance of 230 miles along the Sacramento River. The SRFCP has levees or other facilities on 5 major rivers, 15 creeks, and 13 sloughs. It incorporates 6 bypasses and 11 other constructed or improved channels. The project protects wide areas of the Sacramento Valley along the river and its tributaries, from the town of Tehama to downstream of Rio Vista.

The Sacramento River and Major and Minor Tributaries Project is another large project that was developed to reduce flooding and supply reservoir storage along the Sacramento River. The project also included levee construction and revetment, channel enlargement, and other tributary improvements.

The Sacramento River Project, Chico Landing to Red Bluff, was a modification and extension of the existing SRFCP that provided bank protection and channel improvements. The Sacramento River Bank Protection Project (SRBPP) is an ongoing project to construct bank erosion control works and setback levees within the limits of the existing levee system.

The American River Flood Control Project was developed to reduce flood risk along the lower American River between Carmichael Bluffs and the terminus of the SRFCP levee near the State Fairgrounds. The Middle Creek Project was developed to address localized flooding issues upstream of Clear Lake. The North Fork Feather River Project was developed to address localized flooding near Chester, California. This project consisted of construction of diversion dam, channel, and levees.

USACE bank protection projects in the region include:

- Sacramento River from Chico Landing to Red Bluff
- Diversion dam, channel, and levees on the North Fork Feather River at Chester
- Diversion channel, levees, and a pumping plant on Middle Creek and tributaries near Upper Lake
- Improved channel for the Pit River through Alturas

The region’s eight major reservoirs with flood management reservations are Shasta Lake on the Sacramento River, Folsom Lake on the American River, Lake Oroville on the Feather River, New Bullards Bar Reservoir on the North Yuba River, Indian Valley Reservoir on North Fork Cache Creek, Highland Springs Reservoir on Highland Creek, Black Butte Lake on Stony Creek, and a small reservoir on Adobe Creek. USACE controls the flood management space on Shasta Lake, Folsom Lake, Black Butte, New Bullards Bar, and Lake Oroville reservoirs. Clear Lake, a natural lake, intercepts numerous tributaries to moderate Cache Creek. For the complete list of infrastructure in the Sacramento River Hydrologic Region refer to the California’s Flood Future Report Attachment E: Information Gathering Technical Memorandum.

Today, water resources and flood planning involves additional demands and challenges, such as multiple regulatory processes and permits, coordination with multiple agencies and stakeholders, and increased environmental awareness. These additional complexities call for an Integrated Water Management (IWM) approach that incorporates natural hydrologic, geomorphic, and ecological processes to reduce flood risk. Some agencies are transitioning to IWM which is integral to the 2012 Central Valley Flood Protection Plan (CVFPP).

The CVFPP proposes a system-wide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the State Plan of Flood Control. A substantial portion of the Sacramento River Hydrologic Region is within the implementation area of the CVFPP. The CVFPP is a flood management planning effort that addresses flood risks and ecosystem restoration opportunities in an integrated manner while concurrently improving ecosystem functions, operations and maintenance practices, and institutional support for flood management. Under this approach, California will prioritize investments in flood risk reduction projects and programs that incorporate ecosystem restoration and multi-benefit projects. The CVFPP was adopted by the Central Valley Flood Control Board on June 29, 2012. It is expected that the CVFPP will be updated every 5 years thereafter. The CVFPP proposes to address the following issues:

- Physical improvements in the Sacramento and San Joaquin River basins
- Urban flood protection
- Small community flood protection
- Rural/Agricultural area flood protection
- System improvements
- Non-SPFC levees
- Ecosystem restoration opportunities
- Climate change considerations

PLACEHOLDER Box SR-7 Managing Levee Improvements in Yuba County

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Water Governance

Development of California's water over time has resulted in several different agencies providing multiple layers of governance and management. Local, State, tribal, and federal agencies each provide some level of resource management and have mandates (sometimes conflicting mandates) to meet the needs of the environment, and urban and agricultural water users. For the management of surface water there are approximately 145 settlement contractors and about 32 agricultural, municipal, and industrial water contractors in the region. Responsibilities for flood management are spread among more than 460 agencies, many with different governance structures. There are up to 41 water utilities.

Several resource planning efforts have been developed in the region since 2000. These efforts have been sub regional and regional in scope and are generally supported by specific stakeholder types. Planning goals have generally been focused on sub regional water supply needs or regional in scope to meet environmental needs. Regional planning efforts have included:

- Basinwide Water Management Plan
- Sacramento Valley Water Management Agreement
- Redding Basin Water Resources Management Plan
- Regional Water Use Efficiency Program
- Butte Integrated Water Resources Program
- Yuba-Sutter Regional Recycled Water Master Plan

Regional planning and policy development is now becoming more of a role for the regional IRWM groups. Several groups in the Sacramento River region are currently at some level of plan development. These efforts are providing a vehicle for more collaborative dialogue and intergovernmental cooperation on local water issues. Regional IRWM groups include the following:

- Upper Pit watershed
- Upper Sacramento-McCloud
- Upper Feather River watershed
- Consumnes American Bear Yuba

- North Sacramento Valley Group
- Westside (Yolo, Solano, Napa, Lake,Colusa
- Yuba County

Flood Agencies and Responsibilities

Although primary responsibility might be assigned to a specific local entity, aggregate responsibilities for flood management are spread among more than 460 agencies in the Sacramento River Hydrologic Region with many different governance structures. For a list of the entities that have responsibilities or involvement in flood and water resources management, refer California's Flood Future Report California's Flood Future Report Attachment E: Information Gathering Technical Memorandum. More detail on flood management in the Sacramento Valley can be found in the Central Valley Flood Protection Plan.

Groundwater Governance

California does not have a statewide management program or statutory permitting system for groundwater. However, one of the primary vehicles for implementing local groundwater management in California is a Groundwater Management Plan (GWMP). Some agencies utilize their local police powers to manage groundwater through adoption of groundwater ordinances. Groundwater management also occurs through other avenues such as basin adjudication, IRWMPs, Urban Water Management plans, and Agriculture Water Management plans.

Groundwater Management Assessment

Figure SR-23 shows the location and distribution of the GWMPs within the Sacramento River Hydrologic Region based on a GWMP inventory developed through a joint DWR/Association of California Water Agencies (ACWA) online survey and follow-up communication by DWR in 2011-2012. Table SR-17 furnishes a list of the same. GWMPs prepared in accordance with the 1992 AB 3030 legislation, as well as those prepared with the additional required components listed in the 2002 SB 1938 legislation are shown. Information associated with the GWMP assessment is based on data that was 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 current GWMP assessment.

PLACEHOLDER Figure SR-23 Location of Groundwater Management Plan in the Sacramento River Hydrologic Region

PLACEHOLDER Table SR-17 Groundwater Management Plans in the Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

The GWMP inventory indicates that 39 groundwater management plans exists within the region. Collectively, the 39 GWMPs cover 5,700 square miles or 73 percent of the Bulletin 118-2003 alluvial groundwater basin area in the region. Twenty eight of the 39 GWMPs have been developed or updated to include the SB 1938 requirements and are considered active for the purposes of the Update 2013 GWMP assessment. The active GWMPs cover 4,600 square miles or 59 percent of the Bulletin 118-2003 alluvial groundwater basin area in the region. As of August 2012, five subbasins in the Sacramento Valley Groundwater Basin are identified as high priority and an additional 16 basins and subbasins are identified as medium priority (including 11 subbasins in the Sacramento Valley Groundwater Basin) under the CASGEM Basin Prioritization (see Table SR-3). These 21 high and medium priority basins and subbasins account for about 97 percent of the population and about 89 percent of groundwater supply in the region.

Based on the information compiled through inventory of the GWMPs, an assessment was made to understand and help identify groundwater management challenges and successes in the region, and provide recommendations for improvement. Information associated with the GWMP assessment is based on data that were readily available or received through August 2012 by DWR. The assessment process is briefly summarized below.

The California Water Code §10753.7 requires that six components be included in a groundwater management plan for an agency to be eligible for State funding administered by DWR for groundwater projects, including projects that are part of an integrated regional water management program or plan (IRWM) (see Table SR-18). Three of the components also contain required subcomponents. The requirement associated with the 2011 AB 359 (Huffman) legislation, applicable to groundwater recharge mapping and reporting, did not take effect until January 2013 and was not included in the current GWMP assessment.

In addition to the six required components, Water Code §10753.8 provides a list of twelve components that may be included in a groundwater management plan (Table SR-18). 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 plan (Table SR-18).

As a result, the GWMP assessment was conducted using the following criteria:

- How many of the post SB 1938 GWMPs meet the six required components included in SB 1938 and incorporated into California Water Code §10753.7?
- How many of the post SB 1938 GWMPs include the twelve voluntary components included in California Water Code §10753.8?
- How many of the implementing or signatory GWMP agencies are actively implementing the seven recommended components listed in DWR Bulletin 118 - 2003?

PLACEHOLDER Table SR-18 Assessment for SB 1938 GWMP Required Components, SB 1938 GWMP Voluntary Components, and Bulletin 118-03 Recommended Components

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

In summary, assessment of the groundwater management plans in the Sacramento Hydrologic Region indicates the following:

- Thirteen of the 28 active GWMPs adequately address all of the required components listed under Water Code §10753.7. These thirteen GWMPs cover only 30 percent of the Bulletin 118-2003 alluvial groundwater basin area in the region. Of the rest, 12 plans do not identify activities to evaluate surface water and groundwater interaction. Three plans have the required

BMO component for the surface water and groundwater interaction, but do not have sufficient monitoring protocols that would help ensure correctness and consistency when measuring, recording, and presenting field data. It is common that the plans that fail to meet all the required components, does not address the BMO and Monitoring Protocol subcomponents for surface water-groundwater interaction. Analysis of the GWMPs for other regions also reveals that when a plan lacks BMO details for surface water and groundwater interaction, it generally lacks details for Monitoring Protocols as well.

- As regards the 12 voluntary components listed in Water Code §10753.8, components related to regulatory agencies, groundwater monitoring, and well construction policies are well represented in 90 percent or more of the active GWMPs. GWMPs that include details for well abandonment and destruction, conjunctive use operations, overdraft, and well head protection and recharge issues are provided for in over 70 percent of the plans; the least-included of the voluntary components was the construction and operation component. Based on discussions with a few local agencies, it was apparent that agencies are not always keeping GWMPs updated with future construction and operation projects. Subsequent communication with some local agencies regarding the omission of well abandonment and destruction, and well construction components revealed that those topics were not addressed in the GWMP because the agency felt that County, State, and federal rules met the requirement; if these agencies stated this reliance on external polices and ordinances in their plans, it would have resulted in an higher percentage of compliance. Land use, saline intrusion, groundwater contamination, and groundwater extraction/replenishment topics were not included in some GWMPs because the agencies did not consider the component a significant enough problem in their basin to warrant expensive planning activities, or they were coordinated outside the domain of the GWMP.
- As regards the seven components recommended in Bulletin 118-03, descriptions and details for topics related to management area, future re-evaluation and reporting, and GWMP implementation were well represented in 80 percent or more of the GWMPs. Submittal of annual reports is not required and very few can be found on agencies websites. Of the GWMPs in the region, 75 percent of the plans include guidance details for establishing an advisory committee to guide the GWMP planning and implementation process. The same percentage of GWMPs provided a discussion of how each of the adopted management objectives helps to attain the stated goals, and described how current and planned actions by the managing entity will help meet the adopted management objectives. Monitoring plan descriptions were included in 75 percent of the active GWMPs. The most common reason for not providing monitoring plan details in a GWMP was either the data was not available because the monitoring was being shared or handled by other organizations, or there were concerns about privacy of participating landowners. Two-thirds of the GWMPs made reference to current or future IRWM planning and participation.

The DWR/ACWA survey asked respondents to identify key factors that contributed to the successful implementation of the agency's GWMP. Fifteen agencies from the region participated in the survey. Between 11 and nine respondents identified sharing of ideas and information, data collection and sharing, adequate surface water supply, adequate storage and conveyance, outreach and education, understanding of common interest, and broad stakeholder participation as key factors for successful GWMP implementation while six respondents also identified other components as key factors. The responses to the survey are furnished in Table SR-19.

PLACEHOLDER Table SR-19 Factors Contributing to Successful Groundwater Management Plan Implementation in the Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Survey participants were also asked to identify factors that impeded implementation of the GWMP. Nine survey participants responded. Overall, respondents pointed to a lack of adequate funding as the greatest impediment to GWMP implementation. Funding is a challenging factor for many agencies because implementation and operation of groundwater management projects typically are expensive and because the sources of funding for projects typically are limited to either locally raised monies or to grants from State and federal agencies. Unregulated pumping, understanding of local issues, and access to planning tools were also considered key limiting factors by three respondents. Outreach and education, participation, surface storage and conveyance, and data collection and sharing were also identified as factors that impede successful implementation of GWMPs. The responses to the survey are furnished in Table SR-20.

Finally, the survey asked if the respondents were confident in the long-term sustainability of their current groundwater supply. Thirteen respondents felt long-term sustainability of their groundwater supply was possible; there were no opposing view on long-term sustainability of groundwater in the region.

More detailed information on the DWR/ACWA survey and assessment of the GWMPs are available online from Update 2013, Volume 4, Reference Guide, the article "California's Groundwater Update 2013."

PLACEHOLDER Table SR-20 Factors Limiting to Successful Groundwater Management Plan Implementation in the Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

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 that State law does not occupy the field of groundwater management and does not prevent cities and counties from adopting ordinances to manage groundwater under their police powers. Since 1995, the Baldwin v. Tehama County decision has remained untested; thus the precise nature and extent of the police power of cities and counties to regulate groundwater is still uncertain.

There are a number of groundwater ordinances that have been adopted by counties in the region (Table SR-21). The two most common ordinances are associated with groundwater wells. Nineteen of the 22 counties in the region have groundwater ordinances establishing well construction policies or ordinances that regulate the abandonment and destruction of groundwater wells; 15 of the counties have both. Twelve counties require permits to be submitted for water transfer projects. Three counties (Glenn, Butte, and Lassen) have extensive ordinances pertaining to groundwater management. The ordinances for these three counties include, but are not limited to, basin management objectives, monitoring protocols, agency cooperation, and guidance committees.

PLACEHOLDER Table SR-21 Groundwater Ordinances that Apply to Counties in the Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Special Act Districts

Greater authority to manage groundwater has been granted to a few local agencies or districts created through a special act of the Legislature. The specific authority of each agency varies, but the agencies can be grouped into two general categories: (1) agencies having authority to limit export and extraction (upon evidence of overdraft or threat of overdraft) or (2) agencies lacking authority to limit extraction, but having authority to require reporting of extraction and to levy replenishment fees. There are no Special Act Districts in the Sacramento River Hydrologic Region.

Court Adjudication of Groundwater Rights

Another form of groundwater management in California is through the courts. Of the 24 groundwater adjudications in California, none is in the Sacramento River Hydrologic Region.

Other Groundwater Management Planning Efforts

Groundwater management also occurs through other avenues such as IRWMPs, Urban Water Management plans, and Agriculture Water Management plans. Box SR-8 summarizes these other planning efforts.

PLACEHOLDER Box SR-8 Other Groundwater Management Planning Efforts in the Sacramento River Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Current Relationships with Other Regions and States

As discussed above in the regional resource management conditions the Sacramento River Region is the location of the headwaters of both the State Water Project and the Central Valley Project. As a result this region does have an relationship with the Trinity River through the Trinity River Diversion which passes through this region and water is delivered out of the region through these projects to other many parts of the state. A full understanding of this region is incomplete without an understanding of the interrelationship with these water projects.

Regional Water Planning and Management

Integrated Regional Water Management Coordination and Planning

Eight Integrated Regional Water Management regions have been formed and accepted for the Sacramento River Hydrologic Region. They are identified as the American River Basin, Consumes American Bear Yuba, Northern Sacramento Valley, Upper Feather River watershed, Upper Pit River watershed, Upper Sacramento-McCloud, Westside (Yolo, Solano, Napa, Lake, Colusa), and Yuba County. Presently, the members of each group are either in the process of developing an IRWM Plan for their area or updating an existing Plan to meet current standards. IRWM members and stakeholders have reached out to a wide range of interest groups for assistance with the development of strategies to resolve current and future water management challenges in the region. The Sacramento River region has many tribes and disadvantaged communities and the IRWM groups are involving them in the planning process.

As a result of IRWM planning efforts, local agencies and stakeholders have developed an array of projects and programs to meet their IRWM regional water management objectives. The array includes projects that will sustain existing and future surface water and groundwater supplies and protects the environment. IRWM Regions with existing Plans are implementing projects that include habitat restoration, invasive species control, water use efficiency, and water and wastewater improvements. The newer IRWM regions are prioritizing projects that have been identified through the planning process. These projects include the types being implemented by the established IRWM regions as well as water storage, water quality improvements, habitat an watershed restoration, fish passage, groundwater recharge, flood mitigation and protection, database development, computer modeling of surface and ground water, and well abandonment.

Accomplishments

CALFED Ecosystem Restoration Program

With the signing of the CALFED Programmatic Record of Decision (ROD) in 2000, restoration efforts were put in motion which set the long-term direction of the 30-year CALFED program. The CALFED Program is made up of the Levee System Integrity Program; Water Quality Program; Ecosystem Restoration Program (ERP); Water Use Efficiency Program; Water Transfer Program; Watershed Program; Storage Program; and Conveyance Programs. The implementing agencies are the U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, and the National Marine Fisheries Service.

The intent of the ERP and Watershed Program is to restore the Bay-Delta ecosystem and recover listed species in the watersheds above the Bay-Delta Estuary. The foundation of the ERP is the restoration of processes associated with stream flow, stream channels, watersheds, and floodplains (CDFG 2010). The purpose of the Watershed Program is to promote resource management programs and projects at the watershed level and to improve local management capacity within watershed communities. The program has helped to establish and maintain locally-led watershed restoration, maintenance, conservation, and monitoring efforts, and have improved the scientific basis for flow-related actions.

The ERP was designed as a two stage program. Implementation of Stage 1 began shortly after the issuance of the ROD. Stage 1 covered the first seven years of the 30-year program with the intention of building a foundation for long-term program actions. ERP studies and restoration projects have helped to identify how the Sacramento River flow regime and management actions influence habitats, species, and hydrogeomorphic processes (CDFG 2011). Example Stage 1 restoration projects include:

- Fish passage improvement projects on Butte Creek, Battle Creek, Clear Creek, and Mill Creek
- Habitat restoration in the Yolo Bypass
- Construction of two fish ladders and improvement of fish screens at the Anderson Cottonwood Irrigation District dam
- Restoration of Battle Creek Salmon and Steelhead habitat through the removal of five dams and the addition of screens and ladders to three other dams
- Construction of a new screen structure at Red Bluff Diversion Dam.

Stage 2 is intended to focus on the needs of species and ecosystem components considered to be at high risk. The program focus will be on habitat restoration, rehabilitation of ecological processes, reduction of stressor impacts and on the actions necessary to meet specific information needs (CDFG 2010). Examples of actions and projects identified include:

- Continue to prioritize fish habitat and fish passage restoration projects particularly for spring-run Chinook salmon and steelhead trout
- Restore 50 to 100 miles of tidal channels in the Yolo Bypass by constructing a network of channels within the bypass that connect to the Delta
- Remove small, non-essential dams on gravel-rich streams
- Establish weed control programs to suppress the expansion of tamarisk, giant reed, locust, and other invasive non-native plants degrading habitat quality and native flora
- Design, permit, and construct priority fish screen projects on the Sacramento River
- Investigate whether individual species' respective range of distribution can be extended or changed.

National Marine Fisheries Service Central Valley Salmon and Steelhead Recovery Plan

The Endangered Species Act requires the NMFS to develop and implement recovery plans for listed species. The recovery plan for Sacramento River and Central Valley salmon and steelhead species was published in 2009. The plan identifies site specific actions necessary for species recovery and provides measurable criteria necessary for delisting the species. Priorities for the reintroduction of selected species are also identified. The recovery plan is not a regulatory document but serves as guidance for recovery efforts.

The plan identifies watersheds that have the physical and hydrological characteristics most likely to support viable fish populations and ranks the fish populations as Core 1, Core 2, and Core 3. Core 1 populations have the highest priority for recovery actions based on the potential of the watershed to support independent fish populations. For a fish population within a watershed to be considered Core 1, the population must meet population-level criteria for low risk of extinction. Core 2 populations are considered important to recovery in that they provide for diversity, spatial distribution, and abundance of the species. Core 3 populations are not expected to reach population levels beyond that considered to be at a high risk of extinction but still provide for increased genetic diversity.

Table SR-22 identifies each water body and NMFS priorities for recovery and/or species reintroduction.

PLACEHOLDER Table SR-22 NSF Recovery Priorities for Selected Water Bodies in Sacramento Valley

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

State Water Resources Control Board Instream Flow Studies

The Delta Reform Act of 2009 requires the SWRCB to complete instream flow studies for high priority rivers and streams by 2018. The flow studies are intended to be based on what would be needed if fishery protection was the sole purpose for which waters were put to beneficial use. The studies do not take other beneficial uses into account such as municipal and agricultural water supplies and recreational uses. The Board recognizes that establishing flow objectives is a multidimensional balancing effort and fishery protection represents only one of the factors (SWRCB 2010a). The following are identified for instream flow assessments:

- McCloud River
- Pit River
- Clear Creek
- Cottonwood Creek
- Antelope Creek
- Battle Creek
- Big Chico Creek
- Cow Creek
- Lower Butte Creek
- Mill Creek
- Deer Creek
- Lower Feather River
- American River
- Yuba River
- Bear River

Infrastructure

Freeport Regional Water Facility

The Freeport Regional Water Authority (FRWP) is a cooperative effort of the Sacramento County Water Agency (SCWA) and the East Bay Municipal Utility District (EBMUD) of Oakland to supply surface water from the Sacramento River to customers in central Sacramento County and the East Bay area of California. Construction of the FRWP facilities began in 2007 and became operational in Sacramento in 2011, with the completion of the Vineyard Surface Water Treatment Plant and supplies water to over 40,000 customers.

The diversion point and pumping facilities are located in the South part of Sacramento on the Sacramento River near the small community of Freeport. It provides SCWA with up to 85 million gallons of water per day (mgd) to supplement groundwater use in the central part of the county. EBMUD will use up to 100 mgd of this supply only during dry years, estimated to be three out of every 10 years, as a supplemental water source to complement existing conservation programs. EBMUD's facilities were also completed in 2011, but EBMUD will only use FRWP water during dry years. Water from the FRWP will serve 1.3 million customers in Alameda and Contra Costa counties.

Red Bluff Diversion Dam

The Red Bluff diversion dam was replaced by the Red Bluff Pumping Plant and Fish Screen Project in 2012. The diversion dam, completed in 1964, created a barrier to fish migration. The dam was originally equipped with fish ladders but the effectiveness of the ladders has always been an issue. With the completion of the pumping plant and fish screen, the new facility allows for unimpeded upstream and downstream passage for five runs of listed salmon and green sturgeon. The pumps provide up to 2,000 cfs (with the capacity to deliver 2,500 cfs with additional pumps) for the irrigation of 150,000 acres.

Governance

IRWM Planning

In 2011, the CABY region (Cosumnes, American, Bear, and Yuba) was awarded a Prop 84 planning grant to develop the IRWMP. CABY was awarded a total of $4.615 million from Prop 84 and Prop 1E for planning and implementation for a variety of projects including water meter installation, water conservation planning and habitat improvement.

In 2011, the Regional Water Authority of the American River Basin IRWM received $14.135 million in Prop 84 funding to update the IRWMP and to implement 17 integrated projects by various local agencies and organization in the region. The Authority completed the 2013 IRWMP update and developed a framework for the IRWM process.

The Yuba IRWM region recently received an IRWM planning grant to update their IRWM Plan. The update will include varied outreach to increase stakeholder involvement and coordination and is intended to comply with the IRWM Planning Act and DWR's 2012 IRWM Guidelines. The Plan Update is scheduled for completion and adoption by March 2015.

The Westside IRWM Group completed their IRWM Plan in June 2013 for managing water resources within Lake, Yolo, Napa, Solano, and a portion of Colusa counties through 2035. A formal agreement between the following five agencies established the Westside IRWM Group in 2010: Lake County Watershed Protection District; Napa County Flood Control and Water Conservation District; Solano County Water Agency; Water Resources Association of Yolo County; and Colusa County Resource Conservation District.

Flood

Mid & Upper Sacramento River Regional Planning

The Mid & Upper Sacramento River region of the CVFPP received a $1.2M grant in 2013 to improve local flood emergency plans, improve regional and interagency coordination during flood emergencies, develop standardized emergency responder and flood fight training. The region also received $2.16M planning grant in 2013 to describe current flood management conditions, opportunities for improving flood management, prioritization of potential projects, and development of a preliminary financing plan.

Watershed Planning and Restoration

Colusa County Watershed Management

Colusa County Resource Conservation District completed and released the Colusa Basin Watershed Management Plan in 2012. The Plan is a non-regulatory, community-driven guide which addresses the concerns of a variety of stakeholders. The document sets management goals, objectives, and achievable programs and projects to sustain and enhance watershed functions, including water supply and water quality.

The District also released the final report of the Colusa Basin Watershed Streambank Analysis in 2010. This report addresses water quality issues along tributaries in the Colusa Basin watershed. The focus is on streambank erosion, invasive plant species, and riparian habitat.

The District released the Colusa Basin Watershed Assessment in 2008. The Assessment serves as a history and a current conditions report on watershed conditions, including water quality and water supply.

Battle Creek Restoration

Battle Creek restoration includes the installation of fish ladders and fish screens at three dams. Construction is expected to be completed in 2014. Other restoration actions include the removal of small dams on the South Fork Battle Creek, increasing flows from existing diversions, and hatchery releases. Once restoration actions are completed, 42 miles of additional habitat will be reestablished plus an additional 6 miles of habitat within area tributaries.

Water Supply

City of Davis and City of Woodland Planned Diversion

In September 2009, the Cities of Woodland and Davis established the Woodland-Davis Clean Water Agency (WDCWA), a joint powers authority, to implement and oversee a regional surface water supply project.

The regional project will replace deteriorating groundwater supplies with safe, more reliable surface water supplies from the Sacramento River. Once complete, the project will serve more than two-thirds of the urban population of Yolo County, CA. It will also serve UC Davis, a project partner. The project goals are to provide a new water supply to help meet existing and future needs, improve drinking water quality and improve the quality of treated wastewater.

The project plans include a jointly-owned and operated intake on the Sacramento River (WDCWA in partnership with RD 2035), raw water pipelines connecting the intake to a new regional water treatment plant, and separate pipelines delivering treated water to Woodland, Davis and UC Davis. Improvements to existing water supply systems will vary for Woodland and Davis and will include facilities such as distribution pipelines, water storage tanks and booster pump stations.

The project will divert up to 45,000 acre-feet of water per year from the Sacramento River. Water rights were granted in March 2011, and will be subject to conditions imposed by the State. Water diversions will be limited during summer and other dry periods. A more senior water right for 10,000 acre feet was purchased from the Conaway Preservation Group to provide summer water supply. Groundwater will continue to be used by Woodland and Davis during when demand for water cannot be met with surface water supplies alone.

The water treatment facility will be constructed to supply up to 30 million gallons of water per day, with an option for future expansion to 34 million gallons per day. Of that amount, Woodland's share of treated surface water will be 18 million gallons per day, with Davis' share at 12 million gallons per day. Approximately 5.1 miles of pipeline will transport "raw" water from the surface water intake on the Sacramento River to the water treatment plant located south of Woodland (see map). From there, the treated water will travel 7.8 miles via pipeline to Davis and up to 1.4 miles to Woodland. http://www.wdcwa.com/the_project

Local Groundwater Management

Since 2008, several agencies and communities have developed and adopted groundwater management plans for their region. Agencies responsible for the plans and year of adoption are listed below:

- Colusa County (2008)
- Sacramento Groundwater Authority (2008)
- Reclamation District No. 108 (2008)
- Natomas Central Mutual Water Company (2009)
- South Sutter Water District (2009)
- Yuba County Water Agency (2010)
- City of Vacaville (2011)
- City of Woodland (2011)
- Glenn County (2012)
- Reclamation District No. 1500 (2012)
- Sutter County Public Works Department (2012)
- Tehama County Flood Control Water Conservation District (2012)

Challenges

This section is under development.

Looking to the Future

Future Conditions

Future Scenarios

For Update 2013, the California Water Plan (CWP) evaluates different ways of managing water in California depending on alternative future conditions and different regions of the state. The ultimate goal is to evaluate how different regional response packages, or combinations of resource management strategies from Volume 3, perform under alternative possible future conditions. The alternative future conditions are described as future scenarios. Together the response packages and future scenarios show what management options could provide for sustainability of resources and ways to manage uncertainty and risk at a regional level. The future scenarios are comprised of factors related to future population growth and factors related to future climate change. Growth factors for the Sacramento River region are described below. Climate change factors are described in general terms in Volume 1, Chapter 5, "Managing an Uncertain Future."

PLACEHOLDER Box SR-9 Evaluation of Water Management Vulnerabilities – Sacramento River Region

PLACEHOLDER Box SR-9 Figure SR-A Range of Urban and Agricultural Reliability Results across Scenarios for the Sacramento River Region

PLACEHOLDER Box SR-9 Figure SR-B Range of Change in Groundwater Storage across Scenarios for the Sacramento River Region

PLACEHOLDER Box SR-9 Figure SR-C Range of Instream Flow Reliability across Scenarios for the Sacramento River Region

Water Conservation

The CWP scenario narratives include two types of water use conservation. The first is conservation that occurs without policy intervention (called background conservation). This includes upgrades in plumbing codes and end user actions such as purchases of new appliances and shifts to more water efficient landscape absent a specific government incentive. The second type of conservation expressed in the scenarios is through efficiency measures under continued implementation of existing best management practices in the Memorandum of Understanding (CUWCC 2004). These are specific measures that have been agreed upon by urban water users and are being implemented over time. Any other water conservation measures that require additional action on the part of water management agencies are not included in the scenarios, and would be represented as a water management response.

Sacramento River Growth Scenarios

Future water demand in the Sacramento River hydrologic region is affected by a number of growth and land use factors, such as population growth, planting decisions by farmers, and size and type of urban landscapes. See Table SR-23 for a conceptual description of the growth scenarios used in the CWP. The CWP quantifies several factors that together provide a description of future growth and how growth could affect water demand for the urban, agricultural, and environmental sectors in the Sacramento River region. Growth factors are varied between the scenarios to describe some of the uncertainty faced by water managers. For example, it is impossible to predict future population growth accurately, so the CWP uses three different but plausible population growth estimates when determining future urban water demands. In addition, the CWP considers up to three different alternative views of future development density. Population growth and development density will reflect how large the urban landscape will become in 2050 and are used by the CWP to quantify encroachment into agricultural lands by 2050 in the Sacramento River region.

PLACEHOLDER Table SR-23 Conceptual Growth Scenarios

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

For Update 2013, DWR worked with researchers at the University of California, Davis, to quantify how much growth might occur in the Sacramento River region through 2050. The UPlan model was used to estimate a year 2050 urban footprint under the scenarios of alternative population growth and development density (see http://ice.ucdavis.edu/project/uplan for information on the UPlan model). UPlan is a simple rule-based urban growth model intended for regional or county-level modeling. The needed space for each land use type is calculated from simple demographics and is assigned based on the net attractiveness of locations to that land use (based on user input), locations unsuitable for any development, and a general plan that determines where specific types of development are permitted. Table SR-24 describes the amount of land devoted to urban use for 2006 and 2050, and the change in the urban footprint under each scenario. As shown in the table, the urban footprint grew by about 125 thousand acre under low population growth scenario (LOP) by 2050 relative to 2006 base-year footprint of about 700 thousand acres. Urban footprint under high population scenario (HIP), however, grew by about 355 thousand acres. The effect of varying housing density on the urban footprint is also shown.

PLACEHOLDER Table SR-24 Growth Scenarios (Urban) – Sacramento River

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Table SR-25 describes how future urban growth could affect the land devoted to agriculture in 2050. Irrigated land area is the total agricultural footprint. Irrigated crop area is the cumulative area of agriculture, including multi-crop area, where more than one crop is planted and harvested each year. Each of the growth scenarios shows a decline in irrigated acreage over existing conditions, but to varying degrees. As shown in the table, irrigated crop acreage declines by about 10 thousand acres by year 2050 as a result of low population growth and urbanization in the Sacramento River region, while the decline under high population growth was higher by about 70 thousand acres.

PLACEHOLDER Table SR-25 Growth Scenarios (Agriculture) – Sacramento River

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Sacramento River 2050 Water Demands

In this section a description is provided for how future water demands might change under scenarios organized around themes of growth and climate change described earlier in this chapter. The change in water demand from 2006 to 2050 is estimated for the Sacramento River region for the agriculture and urban sectors under nine growth scenarios and 13 scenarios of future climate change. The climate change scenarios included the 12 CAT scenarios described in Volume 1, Chapter 5 and a 13th scenario representing a repeat of the historical climate (1962-2006) to evaluate a “without climate change” condition.

Figure SR-24 shows the change in water demands for the urban and agricultural sectors under nine growth scenarios, with variation shown across 13 climate scenarios. The nine growth scenarios include three alternative population growth projections and three alternative urban land development densities, as shown in Table SR-23. The change in water demand is the difference between the historical average for 1998 to 2005 and future average for 2043 to 2050. Urban demand is the sum of indoor and outdoor water demand where indoor demand is assumed not to be affected by climate. Outdoor demand, however, depends on such climate factors as the amount of precipitation falling and the average air temperature. The solid blue dot in Figure SR-24 represents the change in water demand under a repeat of historical climate, while the open circles represent change in water demand under 12 scenarios of future climate change.

PLACEHOLDER Figure SR-24 Change in Sacramento River Agricultural and Urban Demands for 117 Scenarios from 2006-2050 (thousand acre-feet per year)

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Urban demand increased under all 9 growth scenarios tracking with population growth. On average, it increased by about 290 thousand acre-feet under the three low population scenarios, 500 thousand acre-feet under the three current trend population scenarios and about 820 thousand acre-feet under the three high population scenarios when compared to historical average of about 840 thousands-acre-feet. The results show change in future urban water demands are less sensitive to housing density assumptions or climate change than to assumptions about future population growth.

Agricultural water demand decreases under all growth scenarios when only considering a repeat of historical climate, primarily due to a reduction in irrigated lands as a result of urbanization and additional water savings from background water conservation. However, when considering the potential effects of future climate change many scenarios show an increase in agricultural water demand even when there is a reduction in irrigated crop area as shown in Table SR-25. Under high population scenarios the decrease was about 50 thousand acre-feet, but under the three low and current trend population scenarios, the average increase in water demand was about 110 thousand acre-feet and 200 thousand acre-feet, respectively, when compared with historical average of 7490 thousand acre-feet. The results show that low density housing would result in more reduction in agricultural demand since more lands are lost under low-density housing than high density housing.

Integrated Water Management Plan Summaries

Inclusion of the information contained in IRWMP's into the CWP Regional Reports has been a common suggestion by regional stakeholders at the Regional outreach meetings since the inception of the IRWM program. To this end the CWP has taken on the task of summarizing readily available integrated water management (IWM) plan in a consistent format for each of the regional reports. This collection of information will not be used to determine IRWM grant eligibility. This effort is ongoing and will be included in the final CWP updates and will include up to 4 pages for each IRWMP in the regional reports.

In addition to these summaries being used in the regional reports we intend to provide all of the summary sheets in one IRWMP Summary "Atlas" as an article included in Volume 4. This atlas will, under one cover, provide an "at-a-glance" understanding of each IRWM region and highlight each region's key water management accomplishments and challenges. The atlas will showcase how the dedicated efforts of individual regional water management groups (RWMGs) have individually and cumulatively transformed water management in California.

All IRWMP's are different in how are organized and therefore finding and summarizing the content in a consistent way proved difficult. It became clear through these efforts that a process is needed to allow those with the most knowledge of the IRWMP's, those that were involved in the preparation, to have input on the summary. It is the intention that this process be initiated following release of the CWP Update 2013 and will continue to be part of the process of the update process for Update 2018. This process will also allow for continuous updating of the content of the atlas as new IRWMP's are released or existing IRWMP's are updated.

As can be seen in Figure SR-25 there are 8 IRWM planning efforts ongoing in the Sacramento River Hydrologic Region.

PLACEHOLDER Figure SR-25 Integrated Water Management Planning in the Sacramento River Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Placeholder Text: At the time of the Public Review Draft the collection of information out of the IRWMP's in the region has not been completed. Below are the basic types of information this effort will summarize and present in the final regional report for each IRWMP available. An opportunity will be provided to those with responsibility over the IRWMP to review these summaries before the reports are final.

Region Description: This section will provide a basic description of the IRWM region. This would include location, major watersheds within the region, status of planning activity, and the governance of the IRWM. In addition, a IRWM grant funding summary will be provided.

Key Challenges: The top five challenges identified by the IRWM would be listed in this section.

Principal Goals/Objective: The top five goals and objectives identified in the IRWMP will be listed in this section.

Major IRWM Milestones and Achievements: Major milestones (Top 5) and achievements identified in the IRWMP would be listed in this section.

Water Supply and Demand: A description (one paragraph) of the mix of water supply relied upon in the region along with the current and future water demands contained in the IRWMP will be provided in this section.

Flood Management: A short (one paragraph) description of the challenges faced by the region and any actions identified by the IRWMP will be provided in this section.

Water Quality: A general characterization of the water quality challenges (one paragraph) will be provided in this section. Any identified actions in the IRWMP will also be listed.

Groundwater Management: The extent and management of groundwater (one paragraph) as described in the IRWMP will be contained in this section.

Environmental Stewardship: Environmental stewardship efforts identified in the IRWMP will be summarized (one paragraph) in this section.

Climate Change: Vulnerabilities to climate change identified in the IRWMP will be summarized (one paragraph) in this section.

Tribal Communities: Involvement with tribal communities in the IRWM will be described (one paragraph) in this section of each IRWMP summary.

Disadvantaged Communities: A summary (one paragraph) of the discussions on disadvantaged communities contained in the IRWMP will be included in this section of each IRWMP summary.

Governance: This section will include a description (less than one paragraph) of the type of governance the IRWM is organized under.

Resource Management Strategies

Volume 3 contains detailed information on the various strategies which can be used by water managers to meet their goals and objectives. A review of the resource management strategies addressed in the available IRWMP's are summarized in Table SR-26.

PLACEHOLDER Table SR-26 Resource Management Strategies addressed in IRWMP's in the Sacramento River Hydrologic Region

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Conjunctive Management and Groundwater Storage

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.

A survey undertaken in 2011-2012 jointly by DWR and ACWA to inventory and assess conjunctive management projects in California is summarized in Box SR-10.

More detailed information about the survey results and a statewide map of the conjunctive management projects and operational information, as of July 2012, is available online from Update 2013, Volume 4, Reference Guide, the article "California's Groundwater Update 2013."

PLACEHOLDER Box SR-10 Statewide Conjunctive Management Inventory Effort in California

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Conjunctive Management Inventory Results

Of the 89 agencies or programs operating a conjunctive management or groundwater recharge program in California identified as part of the DWR/ACWA survey, three agencies are in the Sacramento River Hydrologic Region — Yuba County Water Agency, Sacramento Suburban Water District, and City of Roseville.

Yuba County Water Agency has been operating an in-lieu groundwater recharge program in the North and South Yuba Subbasins since 1991. According to Yuba County Water Agency, the storage of the in-lieu program can go up to 90,000 acre-foot per year when adequate surface water supplies are available.

Sacramento Suburban Water District has been operating an in-lieu conjunctive management program in the North American Subbasin since 1998. The goals and objectives of the program are to address groundwater overdraft, protect groundwater quality, and to accommodate potential water transfer opportunities. The capacity of the program is 32,000 acre-feet per year. On an annual basis, the in-lieu recharge volume has been between 12,500 and 18,000 acre-feet, with a cumulative recharge volume of 176,000 acre-feet since 1998. The estimated extraction in a dry year is up to 4,500 acre-feet, with a cumulative withdrawal of less than 10,000 acre-feet to-date. According to the Sacramento Suburban Water District, legal issues have been the most significant constraints for developing a conjunctive management program, while moderate constraints include political, water quality, and cost issues. Institutional constraints and limited aquifer storage have been identified as minor constraints.

The City of Roseville, in order to address water reliability for its water supply system, developed an aquifer storage and recovery (ASR) program in the North American Subbasin in 2003. The capital cost to develop the ASR program was approximately $3 million. The put and take capacity of Roseville’s program is variable, but currently the program has a capacity of 5 million gallons per day (4,772 acre-feet per year).

More details on the conjunctive management survey results is available online from Update 2013, Volume 4, Reference Guide, the article “California’s Groundwater Update 2013” and DWR Bulletin 118-2003. Additional information regarding conjunctive management in California as well as discussion on associated benefits, costs, and issues can be found online in Update 2013, Volume 3, Chapter 9, the article “Conjunctive Management and Groundwater Storage Resource Management Strategy.”

Climate Change

For over two decades, the State and federal governments have been preparing for climate change effects on natural and built systems with a strong emphasis on water supply. Climate change is already impacting many resource sectors in California, including water, transportation and energy infrastructure, public health, biodiversity, and agriculture (USGCRP, 2009; CNRA, 2009). Climate model simulations based on the Intergovernmental Panel on Climate Change's 21st century scenarios project increasing temperatures in California, with greater increases in the summer. Projected changes in annual precipitation patterns in California will result in changes to surface runoff timing, volume, and type (Cayan, 2008). Recently developed computer downscaling techniques indicate that California flood risks from warm-wet, atmospheric river type storms may increase beyond those that we have known historically, mostly in the form of occasional more-extreme-than-historical storm seasons (Dettinger, 2011).

Currently, enough data exists to warrant the importance of contingency plans, mitigation (reduction) of greenhouse gas (GHG) emissions, and incorporating adaptation strategies; methodologies and infrastructure improvements that benefit the region at present and into the future. While the State is taking aggressive action to mitigate climate change through GHG reduction and other measures (CARB, 2008), global impacts from carbon dioxide and other GHGs that are already in the atmosphere will continue to impact climate through the rest of the century (IPCC, 2007).

Resilience to an uncertain future can be achieved by implementing adaptation measures sooner rather than later. Because of the economic, geographical, and biological diversity of California, vulnerabilities and risks from current and future anticipated changes are best assessed on a regional basis. Many resources are available to assist water managers and others in evaluating their region-specific vulnerabilities and identifying appropriate adaptive actions. (EPA/DWR, 2011; Cal-EMA/CNRA, 2012).

Observations

Due to the region’s large size, complex topography, and multiple climate zones, temperature and precipitation trends have considerable variation. Over the past century, air temperatures measured throughout the region indicate a general warming trend. Regionally-specific air temperature data was retrieved through the Western Regional Climate Center (WRCC). The WRCC has temperature and precipitation data for the past century. Through an analysis of National Weather Service Cooperative

Station and PRISM Climate Group gridded data, scientists from the WRCC have identified 11 distinct regions across the state for which stations located within a region vary with one another in a similar fashion. These 11 climate regions are used when describing climate trends within the state (Abatzoglou et al. 2009). DWR's hydrologic regions, however, do not correspond directly to WRCC's climate regions. A particular hydrologic region may overlap more than one climate region and, hence, have different climate trends in different areas. For the purpose of this regional report, climate trends of the major overlapping climate regions are considered to be relevant trends for respective portions of the overlapping hydrologic region.

Locally in the Sacramento River region, within the WRCC North Central climate region, mean temperatures have increased by about 0.5 to 2.8 °F (0.3 to 1.6 °C) in the past century, with minimum and maximum temperatures increasing by about 1.2 to 2.1 °F (0.6 to 1.2 °C) and 0.1 to 1.4 °F (0.05 to 0.8 °C), respectively. Within the WRCC North East climate region, mean temperatures have increased by about 0.8 to 2.0 °F (0.5 to 1.1 °C) in the past century, with minimum and maximum temperatures increasing by about 0.9 to 2.2 °F (0.5 to 1.2 °C) and by 0.4 to 2.1 °F (0.2 to 1.2 °C), respectively. Within the WRCC Sierra climate region, mean temperatures have increased by about 0.8 to 1.9 °F (0.4 to 1.1 °C) in the past century, with minimum and maximum temperatures increasing and decreasing by about 1.7 to 2.7 °F (0.9 to 1.5 °C) and by -0.3 to 1.3 °F (-0.2 to 0.7 °C), respectively. Within the WRCC Sacramento-Delta climate region, mean temperatures have increased by about 1.5 to 2.4 °F (0.8 to 1.3 °C) in the past century, with minimum and maximum temperatures increasing by about 2.1 to 3.1 °F (1.2 to 1.7 °C) and by 0.7 to 1.9 °F (0.4 to 1.1 °C), respectively (WRCC, 2012).

Over the past century, the mean sea level at the San Francisco tide gage near the Golden Gate Bridge has risen approximately seven inches. Mean annual precipitation in Northern California has increased slightly in the 20th century, and precipitation patterns in the region have considerable geographic and annual variation (DWR, 2006). A hydrologic and climate sensitivity analysis in the Upper Feather River Watershed by Huang et al (2012) indicated that historical air temperature and seasonal streamflow had statistically significant trends, suggesting that warmer air temperatures are causing snowmelt runoff to occur earlier in the water year.

Projections and Impacts

While historic data is a measured indicator of how the climate is changing, it can't project what future conditions may be like under different GHG emissions scenarios. Current climate science uses modeling methods to simulate and develop future climate projections. A recent study by Scripps Institution of Oceanography uses the most sophisticated methodology to date, and indicates by 2060-2069, temperatures will be 3.4to 4.9 °F (1.9 to 2.7 °C) higher across the state than they were from 1985 to1994 (Pierce et al, 2012). Annual mean temperatures by 2060-69 are projected to increase by 4.0 °F (2.2 °C) for the WRCC North Central climate region, with increases of 3.1 °F (1.7 °C) during the winter months and 5.2 °F (2.9 °C) during summer. The WRCC North East climate region has similar projections with annual mean temperatures increasing by 4.7 °F (2.6 °C), winter temperatures increasing by 3.4 °F (1.9 °C), and summer temperatures increasing by 6.5°F (3.6 °C). The WRCC Sierra climate region projections have annual mean temperatures increasing by 4.5 °F (2.5 °C), winter temperatures increasing by 3.4 °F (1.9 °C), and summer temperatures increasing by 5.9 °F (3.3 °C). The WRCC Sacramento-Delta climate region projections have annual mean temperatures increasing by 4.1 °F (2.3 °C), winter temperatures increasing by 3.1 °F (1.7 °C), and summer temperatures increasing by 5.2 °F (2.9 °C). Climate projections for this region, from Cal-Adapt indicate that temperatures between 1990 and 2100 will increase by 8 °F (4.4 °C) in the winter and 12 °F (6.7 °C) in the summer (Cal-EMA and CNRA, 2012).

Changes in annual precipitation across California, either in timing or total amount, will result in changes in type of precipitation (rain or snow) in a given area, and in surface runoff timing and volume. Most climate model precipitation projections for the state anticipate drier conditions in southern California, with heavier and warmer winter precipitation in northern California. Warmer temperatures will result in more precipitation falling as rain instead of snow, decreased snowpack, and increased wildfire risk (Cal-EMA/CNRA, 2012). Modeling results by Huang et al (2012) suggest the Upper Feather River watershed April 1st snowpack would be diminished by 63 percent with 3.6 °F (2 °C) of warming; all modeled climate scenario projections from this study lead to a negative impact on water supply.

More intense wet and dry periods are anticipated, which could lead to flooding in some years and drought in others. In addition, extreme precipitation events are projected to increase with climate change (Pierce, et al., 2012). Recent computer downscaling techniques indicate that California flood risks from warm-wet, atmospheric river type storms may increase beyond those that we have known historically, mostly in the form of occasional more-extreme-than-historical storm seasons (Dettinger, 2011). Winter runoff could result in flashier flood hazards. A higher proportion of precipitation falling as rain instead of snow and increased storm frequency will impact the system's ability to provide effective flood protection. Since there is less scientific detail on localized precipitation changes, there exists a need to adapt to this uncertainty at the regional level (Qian, Y., et al, 2010).

A recent study that explores future climate change and flood risk in the Sierras, using downscaled simulations (refining computer projections to a scale smaller than global models) from three global climate models (GCMs) under an accelerating GHG emissions scenario that is more reflective of current trends, indicates a tendency toward increased three-day flood magnitude. By the end of the 21st century, all three projections yield larger floods for both the moderate elevation northern Sierra Nevada watershed and for the high elevation southern Sierra Nevada watershed, even for GCM simulations with 8 to15 percent declines in overall precipitation. The increases in flood magnitude are statistically significant for all three GCMs for the period 2051 to 2099. By the end of the 21st Century, the magnitudes of the largest floods increase to 110 to 150 percent of historical magnitudes. These increases appear to derive jointly from increases in heavy precipitation amount, storm frequencies, and days with more precipitation falling as rain and less as snow (Das, et al., 2011)

The Sierra Nevada snowpack, is expected to continue to decline as warmer temperatures raise the elevation of snow levels, reduce spring snowmelt, and increase winter runoff. Based upon historical data and modeling, researchers at Scripps Institution of Oceanography project that by the end of this century the Sierra snowpack will experience a 48 to 65 percent loss from its average at the end of the previous century (van Vuuren et al., 2011). In addition, earlier seasonal flows will reduce the flexibility in how the state manages its reservoirs to protect communities from flooding while ensuring a reliable water supply.

Additionally, sea level is projected to continue to rise along California's coast. For the California coast south of Cape Mendocino, the National Research Council projected that sea level will rise 1.5 to 12 inches (3.8 to 30 cm) by 2030, 4.5 to 24 inches (11.4 to 61 cm) by 2050, and 16.5 to 66 inches (41.9 to 168 cm) by 2100 (National Research Council [NRC], 2012). Although the Sacramento River region has no coastline borders, its boundaries extend through the Delta to Chipps Island where waters are influenced by tidal fluctuations and sea level rise.

Warmer waters will result in stress to fisheries, a reduction of coldwater habitat for species of concern, and negatively impact restoration efforts. Thompson et al. (2011) concluded that long-term survival of Spring-run Chinook salmon in Butte Creek (a significant tributary to the Sacramento River) is unlikely under climate change projections and simple changes to water operations are not likely to decrease vulnerabilities to warmer temperatures. With higher summer air temperatures on land, the northern and eastern portions of the region will be at higher risk of wildfire, some having 4 times more risk than current levels by the end of the century (Cal-EMA/CNRA, 2012).

Adaptation

Climate change has the potential to impact the region, which the State depends upon for its vast economic and environmental benefits. These changes will increase the vulnerability of water resources infrastructure including flood control, water supply, and wastewater treatment and disposal. Changes will challenge current operational procedures for the CVP and the SWP, and impact the natural environment by further stressing ecosystems and protective processes. The loss of natural snowpack storage and runoff timing will impact water supply, making the region more dependent on surface storage in reservoirs and groundwater sources. Increased future water demand for both ecological processes and agriculture may be particularly challenging with less natural storage and less overall supply.

Water managers and local agencies must work together determine the appropriate planning approach for their operations and communities. While climate change adds another layer of uncertainty to water planning, it does not fundamentally alter the way water managers already address uncertainty (EPA/DWR, 2011). However, stationarity (the idea that natural systems fluctuate within an unchanging envelope of variability) can no longer be assumed, so new approaches will likely be required (Milly et al., 2008).

Local agencies, as well as federal and State agencies, face the challenge of interpreting new climate change data and information and determining which adaptation methods and approaches are appropriate for their planning needs. The Climate Change Handbook for Regional Water Planning (EPA/DWR, 2011) provides an analytical framework for incorporating climate change impacts into the regional and watershed planning process and considers adaptation to climate change. This handbook provides guidance for assessing the vulnerabilities of California's watersheds and hydrologic regions to climate change impacts, and prioritizing these vulnerabilities.

Integrated Regional Water Management (IRWM) planning is a framework that allows water managers to address climate change on a smaller, more regional scale. Climate change is now a required component of all IRWM plans (DWR 2010). IRWM regions must identify and prioritize their specific vulnerabilities, and identify adaptation strategies that are most appropriate for their sub-regions. Planning strategies to address vulnerabilities and adaptation to climate change should be both proactive and adaptive, starting with strategies that benefit the region in the present-day while adding future flexibility and resilience under uncertainty.

CVP and SWP operations within the region are particularly sensitive to precipitation, reservoir carryover storage levels, demand, and Delta exports. Surface Storage-CALFED is a Resource Management Strategy outlined in CWP that would benefit the CVP and SWP under climate change. Additional reservoir storage would allow greater management flexibility to capture runoff as it occurs and act as a buffer between wet and dry periods. Operations can also be modified as a strategy to improve downstream flood protection while minimizing impacts to water storage in upstream reservoirs. Integrated Flood Management is a Resource Management Strategy employed by DWR in the Yuba-Feather River system. DWR has developed the Forecast-Coordinated Operations Program to reduce downstream peak flows and maintain maximum reservoir capacities through improved forecasting and enhanced communication between local, State, and federal agencies.

Additional resource management strategies found in the CWP not only assist in meeting water management objectives, but also provide benefits for adapting to climate change in the region. These include:

- Conveyance – Regional/local
- System Reoperation
- Conjunctive Management and Groundwater storage
- Precipitation Enhancement
- Surface Storage – Regional/Local
- Pollution Prevention
- Ecosystem Restoration
- Forest Management
- Land Use Planning and Management
- Recharge Area Protection
- Watershed Management

The myriad of resources and choices available to managers can seem overwhelming, and the need to take action given uncertain future conditions is daunting. However, there are many actions that water managers can take to prepare for climate change, regardless of the magnitude of future warming. These actions often provide economic and public health co-benefits. Water and energy conservation are examples of strategies that make sense with or without the additional pressures of climate change. Conjunctive management projects that manage surface and groundwater in a coordinated fashion could provide a buffer against variable annual water supplies. Forecast-coordinated operations would provide flexibility for water managers to respond to weather conditions as they unfold.

Water managers will need to consider both the natural and built environments as they plan for the future. Stewardship of natural areas and protection of biodiversity are critical for maintaining ecosystem services important for human society such as carbon sequestration, pollution remediation, and habitat for pollinators. Increased cross-sector collaboration between water managers, land use planners and ecosystem managers provides opportunities for identifying common goals and actions needed to achieve resilience to climate change and other stressors.

Mitigation

California’s water sector has a large energy footprint, consuming 7.7% of statewide electricity (CPUC, 2010). Energy is used in the water sector to extract, convey, treat, distribute, use, condition, and dispose of water. Figure 3-26, Water-Energy Connection in Volume 1, CA Water Today shows all of the connections between water and energy in the water sector; both water use for energy generation and energy use for water supply activities. The regional reports in Update 2013 are the first to provide detailed information on the water-energy connection, including energy intensity (EI) information at the regional level. This EI information is designed to help inform the public and water utility managers about the relative energy requirements of the major water supplies used to meet demand. Since energy usage is related to Greenhouse Gas (GHG) emissions, this information can support measures to reduce GHG's, as mandated by the State.

Figure SR-26 shows the amount of energy associated with the extraction and conveyance of 1 acre-foot of water for each of the major sources in this region. The quantity used is also included, as a percent. For reference, Figure 3-26, Water-Energy Connection in CA Water Today, Volume 1 highlights which water-energy connections are illustrated in Figure SR-26; only extraction and conveyance of raw water. Energy required for water treatment, distribution, and end uses of the water are not included. Not all water types are available in this region. Some water types flow by gravity to the delivery location and therefore do not require any energy to extract or convey (represented by a white light bulb).

Recycled water and water from desalination used within the region are not show in Figure SR-26 because their energy intensity differs in important ways from those water sources. The energy intensity of both recycled and desalinated water depend not on regional factors but rather on much more localized, site, and application specific factors. Additionally, the water produced from recycling and desalination is typically of much higher quality than the raw (untreated) water supplies evaluated in Figure SR-26. For these reasons, discussion of energy intensity of desalinated water and recycled water are included in Volume 3, Resource Management Strategies.

Energy intensity, sometimes also known as embedded energy, is the amount of energy needed to extract and convey (Extraction refers to the process of moving water from its source to the ground surface. Many water sources are already at ground surface and require no energy for extraction, while others like groundwater or sea water for desalination require energy to move the water to the surface. Conveyance refers to the process of moving water from a location at the ground surface to a different location, typically but not always a water treatment facility. Conveyance can include pumping of water up hills and mountains or can occur by gravity) an acre-foot of water from its source (e.g. groundwater or a river) to a delivery location, such as a water treatment plant or a State Water Project (SWP) delivery turnout (Energy from low-head pump lifts (less than 50 feet) used to divert water out of river channels or canals has been excluded from the calculations). Energy intensity should not be confused with total energy — that is, the amount of energy (e.g. kWh) required to deliver all of the water from a water source to customers within the region. Energy intensity focuses not on the total amount of energy used to deliver water, but rather the energy required to deliver a single unit of water (in kWh/acre-foot). In this way, energy intensity gives a normalized metric which can be used to compare alternative water sources.

In most cases, this information will not be of sufficient detail for actual project level analysis. However, these generalized, region-specific metrics provide a range in which energy requirements fall. The information can also be used in more detailed evaluations using tools such as WeSim (http://www.pacinst.org/publication/wesim/) which allows modeling of water systems to simulate outcomes for energy, emissions, and other aspects of water supply selection. It's important to note that water supply planning must take into consideration a myriad of different factors in addition to energy impacts; costs, water quality, opportunity costs, environmental impacts, reliability and other many other factors.

Energy intensity is closely related to Greenhouse Gas (GHG) emissions, but not identical, depending on the type of energy used (see CA Water Today, Water-Energy, Volume 1). In California, generation of 1 megawatt-hour (MWh) of electricity results in the emission of about 1/3 of a metric ton of GHG, typically referred to as carbon dioxide equivalent or CO2e (eGrid, 2012). This estimate takes into account the use of GHG-free hydroelectricity, wind, and solar and fossil fuel sources like natural gas and coal. The GHG emissions from a specific electricity source may be higher or lower than this estimate.

Reducing GHG emissions is a State mandate. Water managers can support this effort by considering energy intensity factors, such as those presented here, in their decision making process. Water use efficiency and related best management practices can also reduce GHGs (See Volume 2, Resource Management Strategies).

Accounting for Hydroelectric Energy

Generation of hydroelectricity is an integral part of many of the State's large water projects. In 2007, hydroelectric generation accounted for nearly 15% of all electricity generation in California. The State Water Project, Central Valley Project, Los Angeles Aqueduct, Mokelumne Aqueduct, and Hetch Hetchy Aqueducts all generate large amounts of hydroelectricity at large multi-purpose reservoirs at the heads of each system. In addition to hydroelectricity generation at head reservoirs, several of these systems also generate hydroelectric energy by capturing the power of water falling through pipelines at in-conduit generating facilities (In-conduit generating facilities refer to hydroelectric turbines that are placed along pipelines to capture energy as water runs downhill in a pipeline (conduit)). Hydroelectricity is also generated at hundreds of smaller reservoirs and run-of-the-river turbine facilities.

Hydroelectric generating facilities at reservoirs provide unique benefits. Reservoirs like the State Water Project's Oroville Reservoir are operated to build up water storage at night when demand for electricity is low, and release the water during the day time hours when demand for electricity is high. This operation, common to many of the state's hydropower reservoirs, helps improve energy grid stabilization and reliability and reduces GHG emissions by displacing the least efficient electricity generating facilities. Hydroelectric facilities are also extremely effective for providing back-up power supplies for intermittent renewable resources like solar and wind power. Because the sun can unexpectedly go behind a cloud or the wind can die down, intermittent renewables need back up power sources that can quickly ramp up or ramp down depending on grid demands and generation at renewable power installations.

Despite these unique benefits and the fact that hydroelectric generation was a key component in the formulation and approval of many of California's water systems, accounting for hydroelectric generation in energy intensity calculations is complex. In some systems like the SWP and CVP, water generates electricity and then flows back into the natural river channel after passing through the turbines. In other systems like the Mokelumne aqueduct water can leave the reservoir by two distinct out flows, one that generates electricity and flows back into the natural river channel and one that does not generate electricity and flows into a pipeline flowing into the East Bay Municipal Utility District service area. In both these situations, experts have argued that hydroelectricity should be excluded from energy intensity calculations because the energy generation system and the water delivery system are in essence separate (Wilkinson, 2000).

DWR has adopted this convention for the energy intensity for hydropower in the regional reports. All hydroelectric generation at head reservoirs has been excluded from Figure SR-26. Consistent with

Wilkinson (2000) and others, DWR has included in-conduit and other hydroelectric generation that occurs as a consequence of water deliveries, such as the Los Angeles Aqueduct's hydroelectric generation at San Francisquito, San Fernando, Foothill and other power plants on the system (downstream of the Owen's River Diversion Gates). DWR has made one modification to this methodology to simplify the display of results: energy intensity has been calculated at each main delivery point in the systems; if the hydroelectric generation in the conveyance system exceeds the energy needed for extraction and conveyance, the energy intensity is reported as zero (0). I.e., no water system is reported as a net producer of electricity, even though several systems do produce more electricity in the conveyance system than is used (e.g., Los Angeles Aqueduct, Hetch Hetchy Aqueduct). (For detailed descriptions of the methodology used for the water types presented, see Technical Guide, Volume 5.)

PLACEHOLDER Figure SR-26 Energy Intensity of Raw Water Extraction and Conveyance in the Sacramento Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

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Table SR-1 Alluvial Groundwater Basins and Subbasins within the Sacramento River Hydrologic Region

Basin/Subbasin	Basin Name	Basin/Subbasin	Basin Name
5-1	Goose Lake Valley	5-21.65	South American
5-1.01	Lower Goose Lake Valley	5-21.66	Solano
5-1.02	Fandango Valley	5-21.67	Yolo
5-2	Alturas Area	5-21.68	Capay Valley
5-2.01	South Fork Pitt River	5-30	Lower Lake Valley
5-2.02	Warm Springs Valley	5-31	Long Valley
5-3	Jess Valley	5-35	Mccloud Area
5-4	Big Valley	5-36	Round Valley
5-5	Fall River Valley	5-37	Toad Well Area
5-6	Redding Area	5-38	Pondosa Town Area
5-6.01	Bowman	5-40	Hot Springs Valley
5-6.02	Rosewood	5-41	Egg Lake Valley
5-6.03	Anderson	5-43	Rock Prairie Valley
5-6.04	Enterprise	5-44	Long Valley
5-6.05	Millville	5-45	Cayton Valley
5-6.06	South Battle Creek	5-46	Lake Britton Area
5-7	Lake Almanor Valley	5-47	Goose Valley
5-8	Mountain Meadows Valley	5-48	Burney Creek Valley
5-9	Indian Valley	5-49	Dry Burney Creek Valley
5-10	American Valley	5-50	North Fork Battle Creek
5-11	Mohawk Valley	5-51	Butte Creek Valley
5-12	Sierra Valley	5-52	Gray Valley
5-12.01	Sierra Valley	5-53	Dixie Valley
5-12.02	Chilcoot	5-54	Ash Valley
5-13	Upper Lake Valley	5-56	Yellow Creek Valley
5-14	Scotts Valley	5-57	Last Chance Creek Valley
5-15	Big Valley	5-58	Clover Valley
5-16	High Valley	5-59	Grizzly Valley
5-17	Burns Valley	5-60	Humbug Valley
5-18	Coyote Valley	5-61	Chrome Town Area
5-19	Collayomi Valley	5-62	Elk Creek Area
5-20	Berryessa Valley	5-63	Stonyford Town Area
5-21	Sacramento Valley	5-64	Bear Valley
5-21.50	Red Bluff	5-65	Little Indian Valley
5-21.51	Corning	5-66	Clear Lake Cache Formation
5-21.52	Colusa	5-68	Pope Valley
5-21.53	Bend	5-86	Joseph Creek
5-21.54	Antelope	5-87	Middle Fork Feather River
5-21.55	Dye Creek	5-88	Stony Gorge Reservoir
5-21.56	Los Molinos	5-89	Squaw Flat
5-21.57	Vina	5-90	Funks Creek
5-21.58	West Butte	5-91	Antelope Creek
5-21.59	East Butte	5-92	Blanchard Valley
5-21.60	North Yuba	5-93	North Fork Cache Creek
5-21.61	South Yuba	5-94	Middle Creek
5-21.62	Sutter	5-95	Meadow Valley

Basin/Subbasin	Basin Name	Basin/Subbasin	Basin Name
5-21.64	North American		

Table SR-2 Number of Well Logs by County and Use for the Sacramento River Hydrologic Region (1977-2010)

County	Total Number of Well Logs by Well Use						
	Domestic	Irrigation	Public Supply	Industrial	Monitoring	Other	Total Well Records
Modoc	1,320	381	17	6	103	188	2,015
Shasta	7,453	145	160	32	1,210	252	9,252
Tehama	7,889	614	79	19	540	331	9,472
Glenn	1,784	845	18	20	322	165	3,154
Butte	8,678	1,170	108	48	1,076	447	11,527
Plumas	2,876	76	116	22	212	148	3,450
Lake	2,757	500	105	13	283	239	3,897
Colusa	815	425	36	25	192	108	1,601
Sutter	1,375	663	66	25	422	107	2,658
Yuba	3,931	282	69	17	625	46	4,970
Sierra	253	23	21	1	56	35	389
Nevada	13,284	27	151	10	468	53	13,993
Placer	9,461	67	152	8	941	228	10,857
Sacramento	3,991	302	209	41	6,858	1,754	13,155
El Dorado	9,165	176	180	3	563	114	10,201
Yolo	1,355	828	89	42	1,027	300	3,641
Solano	1,873	257	52	36	1,616	280	4,114
Total Well Records	**78,260**	**6,781**	**1,628**	**368**	**16,514**	**4,795**	**108,346**

Table SR-3 CASGEM Groundwater Basin Prioritization for the Sacramento River Hydrologic Region

Basin Prioritization	Count	Basin/Subbasin Number	Basin Name	Subbasin Name	2010 Census Population
High	1	5-21.58	SACRAMENTO VALLEY	West Butte	36,152
High	2	5-21.65	SACRAMENTO VALLEY	South American	718,113
High	3	5-21.64	SACRAMENTO VALLEY	North American	832,746
High	4	5-21.57	SACRAMENTO VALLEY	Vina	71,397
High	5	5-21.67	SACRAMENTO VALLEY	Yolo	194,158
Medium	1	5-21.52	SACRAMENTO VALLEY	Colusa	48,369
Medium	2	5-21.54	SACRAMENTO VALLEY	Antelope	6,124
Medium	3	5-12.01	SIERRA VALLEY	Sierra Valley	2,196
Medium	4	5-21.59	SACRAMENTO VALLEY	East Butte	38,465
Medium	5	5-21.51	SACRAMENTO VALLEY	Corning	18,852
Medium	6	5-14	SCOTTS VALLEY		6,553
Medium	7	5-21.62	SACRAMENTO VALLEY	Sutter	82,125
Medium	8	5-6.04	REDDING AREA	Enterprise	68,627
Medium	9	5-15	BIG VALLEY		6,344
Medium	10	5-21.66	SACRAMENTO VALLEY	Solano	119,263
Medium	11	5-6.03	REDDING AREA	Anderson	52,937
Medium	12	5-6.01	REDDING AREA	Bowman	7,165
Medium	13	5-21.50	SACRAMENTO VALLEY	Red Bluff	28,053
Medium	14	5-21.61	SACRAMENTO VALLEY	South Yuba	45,014
Medium	15	5-21.56	SACRAMENTO VALLEY	Los Molinos	2,220
Medium	16	5-21.55	SACRAMENTO VALLEY	Dye Creek	1,626
Low	7	See Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013			
Very Low	60	See Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013			
Total:	**88**	**Population of Groundwater Basin Area:**			**2,450,515**

Table SR-4 Groundwater Level Monitoring Wells by Monitoring Entity in the Sacramento River Hydrologic Region

State and Federal Agencies	Number of Wells
DWR	635
USGS	4
USBR	150
Total State and Federal Wells:	**789**
Monitoring Cooperators	**Number of Wells**
Colusa Rancheria	8
Sacramento County	18
Sutter County	6
Sutter South Water District	1
Yolo County Flood Control and Water Conservation District	118
Yuba County	30
Total Cooperator Wells:	**181**
CASGEM Monitoring Entities	**Number of Wells**
Butte County Department of Water & Resource Conservation	70
City of Roseville	11
Colusa County	28
County of Glenn, Department of Agriculture	82
Feather Water District	4
Reclamation District No. 1500	7
Sacramento Central Groundwater Authority	24
Sacramento Groundwater Authority	35
Shasta County	3
South Sutter Water District	20
Sutter Extension Water District	9
Tehama County Flood Control & Water Conservation District	27
Water Resources Association of Yolo County	6
Yuba County Water Agency	10
Total CASGEM Monitoring Entities:	**336**
Grand Total:	**1,306**

Note: Table includes groundwater level monitoring wells having publicly available online data.

Table represents monitoring information as of July, 2012.

Table SR-5 Sources of Groundwater Quality Information

Agency	Links to Information
State Water Resources Control Board	Groundwater • Communities that Rely on a Contaminated Groundwater Source for Drinking Water • Nitrate in Groundwater: Pilot Projects in Tulare Lake Basin/Salinas Valley • Hydrogeologically Vulnerable Areas • Aquifer Storage and Recovery • Central Valley Salinity Alternatives for Long-Term Sustainability (CV-Salts) GAMA • GeoTracker GAMA (Monitoring Data) • Domestic Well Project • Priority Basin Project • Special Studies Project • California Aquifer Susceptibility Project Contaminant Sites • Land Disposal Program • Department of Defense Program • Underground Storage Tank Program • Brownfields
California Department of Public Health	Division of Drinking Water and Environmental Management • Drinking Water Source Assessment and Protection (DWSAP) Program • Chemicals and Contaminants in Drinking Water • Chromium-6 • Groundwater Replenishment with Recycled Water
Department of Water Resources	Groundwater Information Center • Bulletin 118 Groundwater Basins • California Statewide Groundwater Elevation Monitoring (CASGEM) • Groundwater Level Monitoring • Groundwater Quality Monitoring • Well Construction Standards • Well Completion Reports
Department of Toxic Substances Control	• EnviroStor
Department of Pesticide Regulation	Groundwater Protection Program • Well Sampling Database • Groundwater Protection Area Maps
U.S. Environmental Protection Agency	US EPA STORET Environmental Data System
United States Geological Survey	USGS Water Data for the Nation

Table SR-6 Federally Recognized Tribes in Sacramento River Hydrologic Region

Name of Tribe	Cultural Affiliation
Alturas Indian Rancheria	Achomawi
Berry Creek Rancheria of Maidu Indians	Tyme Maidu
Big Valley Band of Pomo Indians	Pomo
Cachil DeHe Band of Wintun Indians of the Colusa Indian Community	Wintun
Cedarville Rancheria	Northern Paiute
Cortina Indian Rancheria of Wintun Indians	Wintun
Elem Indian Colony of Pomo Indians	Pomo
Enterprise Rancheria of Maidu Indians	
Fort Bidwell Indian Community of the Fort Bidwell Reservation of California	Northern Paiute
Greenville Indian Rancheria of Maidu Indians	Maidu
Grindstone Indian Rancheria of Wintun-Wailaki Indians of California	Wintun, Wailaki
Habematolel Pomo of Upper Lake	Pomo
Koi Nation - Lower Lake Rancheria	Pomo
Mechoopda Indian Tribe of Chico	Maidu
Middletown Rancheria of Pomo Indians	Pomo, Lake Miwok
Mooretown Rancheria of Maidu Indians	Maidu
Paskenta Band of Nomlaki Indians	Nomlaki
Pit River Tribe (includes XL Ranch, Big Bend, Likely, Lookout, Montgomery Creek and Roaring Creek Rancherias)	Achomawi (Achumawi, Ajumawi), Aporidge, Astariwawi (Astarawi), Atsuge (Atsugewi), Atwamsini
Hanhawi (Hammawi), Hewisedawi, Ilmawi,	
Itsatawi, Kosalextawi (Kosalektawi), Madesi	
Redding Rancheria	Wintu, Yana, Pit River
Robinson Rancheria of Pomo Indians	Pomo

Name of Tribe	Cultural Affiliation
Scotts Valley Band of Pomo Indians	Pomo
United Auburn Indian Community of the Auburn Rancheria	Miwok, Maidu

Source: Federal Register, Vol. 77, No. 155, August 10, 2012, http://www.gpo.gov/fdsys/pkg/FR-2012-08-10/pdf/2012-19588.pdf, accessed on August 22, 2012.

Table SR-7 Irrigated Acreage Estimates in the Sacramento River Hydrologic Region

Region	DAU(s)	Crop Type (Acreage)
Sacramento Valley Floor	167, 166, 164, 170, 144, 162, 172, 142, 173, 186, 191, 163, 171, 168	Grain (117,900,
		Rice (504,300)
		Alfalfa (135,800)
		Pasture (125,100)
		Almonds/Pistachios (150,300)
		Other Deciduous (236,400)
		Tomatoes (70,000)
Pit River Watershed	132, 130, 134	Pasture (74,500)
		Alfalfa (24,800)
		Grain (15,500)
Redding/Cow Creek	145, 143, 141	Pasture (22,400)
Feather River Watershed	154	Pasture (46,000)
		Alfalfa (8,600)

Table SR-8 Sacramento River Hydrologic Region Average Annual Groundwater Supply by Planning Area (PA) and by Type of Use (2005-2010)

Sacramento River Hydrologic Region		Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groundwater	
PA Number	**PA Name**	**TAF**	**%**	**TAF**	**%**	**TAF**	**%**	**TAF**	**%**
501	Shasta – Pit	83.2	25%	11.3	67%	0.0	0%	94.5	26%
502	Upper Northwest Valley	3.3	35%	0.4	62%	0.0	0%	3.7	37%
503	Lower Northwest Valley	238.4	51%	47.9	79%	0.0	0%	286.3	55%
504	Northeast Valley	175.3	57%	41.5	51%	0.0	0%	216.8	56%
505	Southwest	42.1	81%	5.1	54%	0.0	0%	47.1	77%
506	Colusa Basin	498.7	26%	14.0	100%	9.2	6%	521.9	25%
507	Butte – Sutter – Yuba	508.3	21%	47.2	69%	10.9	4%	566.4	21%
508	Southeast	44.0	13%	23.3	20%	0.0	0%	67.3	15%
509	Central Basin West	473.0	57%	47.0	65%	0.0	0%	520.0	58%
510	Sacramento Delta	19.5	4%	4.6	15%	0.0	0%	24.2	4%
511	Central Basin East	208.5	47%	186.4	43%	0.0	0%	394.9	45%
2005-10 Annual Average HR Total:		**2,294.2**	**30%**	**428.6**	**47%**	**20.1**	**4%**	**2,742.9**	**30%**

Note: 1) TAF = thousand acre-feet

2) Percent use is the percent of the total water supply that is met by groundwater, by type of use.

3) 2005-10 Precipitation equals 96% of the 30-yr average for the Sacramento River Region

4) Total Supply = Groundwater + Surface Water + Reuse

Table SR-9 Sacramento River Hydrologic Region Average Annual Groundwater Supply by County and by Type of Use (2005-2010)

Sacramento River 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**	**%**	**TAF**	**%**	**TAF**	**%**	**TAF**	**%**
Butte	367.7	32%	51.0	73%	9.1	9%	427.7	32%
Colusa	231.6	19%	7.9	98%	7.7	5%	247.2	18%
El Dorado	0.6	4%	9.0	15%	0.0	0%	9.6	13%
Glenn	277.5	28%	11.0	100%	3.3	4%	291.8	27%
Lake	36.5	80%	4.6	52%	0.0	0%	41.0	75%
Modoc	90.9	25%	3.0	92%	0.0	0%	93.9	20%
Nevada	1.0	3%	8.3	29%	0.0	0%	9.3	14%
Placer	17.7	9%	20.8	19%	0.0	0%	38.5	13%
Plumas	14.4	18%	9.0	65%	0.0	0%	23.4	25%
Sacramento	179.1	44%	191.2	46%	0.1	0%	370.5	44%
Shasta	24.1	11%	40.2	47%	0.0	0%	64.3	21%
Sierra	23.9	30%	1.0	87%	0.0	0%	24.9	30%
Solano	254.6	46%	20.1	21%	0.0	0%	274.8	43%
Sutter	252.8	26%	9.6	37%	0.0	0%	262.4	24%
Tehama	227.6	66%	20.6	92%	0.0	0%	248.2	67%
Yolo	360.4	43%	38.8	68%	0.0	0%	399.2	44%
Yuba	74.4	21%	19.1	98%	0.0	0%	93.5	24%
2005-10 Annual Ave. Total:	**2,434.7**	**31%**	**465.2**	**45%**	**20.2**	**4%**	**2,920.0**	**31%**

Note: 1) TAF = thousand acre-feet

2) Percent use is the percent of the total water supply that is met by groundwater, by type of use.

3) 2005-10 Precipitation equals 96% of the 30-yr average for the Sacramento River Region

4) Total Supply = Groundwater + Surface Water + Reuse

Table SR-10 Sacramento River Hydrologic Region Water Balance Summary, 2001-2010

Table SR-11 Sacramento River Hydrologic Region water balance for 2001-2010 (in TAF)

Sacramento River (TAF)	Water Year (Percent of Normal Precipitation)									
	2001 (67%)	2002 (91%)	2003 (99%)	2004 (90%)	2005 (127%)	2006 (139%)	2007 (65%)	2008 (68%)	2009 (80%)	2010 (96%)
Water Entering the Region										
Precipitation	35,895	49,488	54,171	49,026	69,646	76,503	35,542	37,535	44,229	52,576
Inflow from Oregon/Mexico	0	0	0	0	0	0	0	0	0	0
Inflow from Colorado River	0	0	0	0	0	0	0	0	0	0
Imports from Other Regions	700	2,067	2,260	2,374	4,268	8,739	2,220	1,817	1,420	2,198
Total	**36,595**	**51,555**	**56,431**	**51,400**	**73,914**	**85,242**	**37,762**	**39,352**	**45,649**	**54,774**
Water Leaving the Region										
Consumptive Use of Applied Water * (Ag, M&I, Wetlands)	5,456	5,598	4,885	6,029	4,707	5,093	5,944	5,923	5,573	4,790
Outflow to Oregon/Nevada/Mexico	0	0	0	0	0	0	0	0	0	0
Exports to Other Regions	4,657	6,783	7,686	7,485	7,908	6,676	5,958	3,452	3,309	6,825
Statutory Required Outflow to Salt Sink	5,663	5,058	6,586	6,692	7,110	12,192	6,539	4,464	6,745	7,388
Additional Outflow to Salt Sink	3,940	4,407	7,692	8,381	8,073	33,678	1,715	2,211	2,033	4,923
Evaporation, Evapotranspiration of Native Vegetation, Groundwater Subsurface Outflows, Natural and Incidental Runoff, Ag Effective Precipitation & Other Outflows	20,439	30,328	28,780	26,714	44,359	28,830	22,503	27,403	29,294	30,229
Total	**40,155**	**52,174**	**55,629**	**55,301**	**72,157**	**86,469**	**42,659**	**43,452**	**46,953**	**54,155**
Change in Supply										
[+] Water added to storage [-] Water removed from storage										
Surface Reservoirs	-2,412	799	2,273	-2,263	2,968	349	-2958	-2051	664	2364
Groundwater **	-1,148	-1,418	-1,470	-1,639	-1,211	-1576	-1939	-2049	-1968	-1745
Total	**-3,560**	**-619**	**803**	**-3,902**	**1,757**	**-1227**	**-4897**	**-4100**	**-1304**	**619**
Applied Water * (Ag, Urban, Wetlands) (compare with Consumptive Use)	9,096	9,418	8,439	9,915	8,196	8,734	9,868	9,816	9,284	8,343

* Definition: Consumptive use is the amount of applied water used and no longer available as a source of supply. Applied water is greater than consumptive use because it includes consumptive use, reuse, and outflows.

** Definition: Change in Supply: Groundwater – The difference between water extracted from and water recharged into groundwater basins in a region. All regions and years were calculated using the following equation:

change in supply: groundwater = intentional recharge + deep percolation of applied water + conveyance deep percolation and seepage - withdrawals

This equation does not include unknown factors such as natural recharge and subsurface inflow and outflow. For further details, refer to Volume 4, Reference Guide – *California's Groundwater Update 2013* and Volume 5 Technical Guide.

n/a = not applicable

Table SR-11 Estimates of Annual CVP/SWP Water Demand by Region

Project	Regions	Million Acre-Feet
SWP	Delta and South Delta	1.9
	Feather River Service Area	1.1
CVP	Delta and South of Delta	3.5
	Sacramento Valley	3.4

Source: CDWR 2002, USBR 2004

Table SR-12 Estimates of CVP Deliveries by Water User (million acre-feet)

Water Use Area	Water Contracts	Agricultural Water Service Contracts	M&I Service Contracts	Refuge Water Supplies with Losses
Delta and South of Delta	0.9	2.1	0.3	0.2
Sacramento Valley	2.2	0.4	0.5	0.3
Total	3.1	2.5	0.8	0.5

Source: USBR 2004

Table SR-13 Summary of Large, Medium, Small, and Very Small Community Drinking Water Systems in the Sacramento River Hydrologic Region

	Community Water Systems (CWS)		Population Served	
Water System Size	**(Systems)**	**(%)**	**(Population)**	**(%)**
Large (> 10,000 people)	44	9%	2,545,212	85%
Medium (3,301 – 10,000 people)	42	8%	270,019	9%
Small (500 – 3,300 people)	85	17%	125,252	4%
Very Small (<500 people)	333	66%	46,330	2%
CWS that Primarily Provide Wholesale Water	0	0	---	---
TOTAL	**504**		**2,986,813**	

Table SR-14 Summary of Small, Medium, and Large Community Drinking Water Systems in the Sacramento River Hydrologic Region that Rely on One or More Contaminated Groundwater Well(s)

	Small Systems ≤ 3,300	Medium Systems 3,301 – 10,000	Large Systems > 10,000	Total
No. of Affected Community Drinking Water Systems	45	5	11	61
No. of Affected Community Drinking Water Wells	57	12	32	101

Source: Water Boards 2012 Draft Report on "Communities that Rely on Contaminated Groundwater"

Note: 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 SR-15 Summary of Contaminants Affecting Community Drinking Water Systems in the Sacramento River Hydrologic Region

Principal contaminant (PC)	Community drinking water systems where PC exceeds the Primary MCL	Community drinking water wells where PC exceeds the Primary MCL
Arsenic	41	73
Nitrate	9	9
Tetrachloroethylene (PCE)	7	10
Gross alpha particle activity	3	4
Benzene	2	2

Source: Water Boards 2012 Draft Report on “Communities that Rely on Contaminated Groundwater”

Notes:

1. Only the 5 most prevalent contaminants are shown.

2. 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 SR-16 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Sacramento River Hydrologic Region

A. Redding Area Groundwater Basin Spring 2005-10 Change in Storage Estimates

Reporting Area (Acres):	171,568		
Non-Reporting Area (Acres):	176, 515		
Period Spring - Spring	**Average Change in Groundwater Elevation (feet)**	**Estimated Change in Storage in TAF**	
		Assuming Specific Yield = 0.07	**Assuming Specific Yield = 0.17**
2005-2006	3.0	36.1	87.8
2006-2007	-2.7	-32.2	-78.2
2007-2008	-0.1	-0.7	-1.8
2008-2009	-1.8	-21.9	-53.3
2009-2010	0.8	9.4	22.7
2005-2010 (total)	-0.8	-9.4	-22.8

Note: Changes in groundwater elevation and storage are calculated for reporting area only.

B. Sacramento Valley Groundwater Basin Spring 2005-10 Change in Storage Estimates

Reporting Area (Acres):	3,070,427		
Non-Reporting Area (Acres):	1,052,799		
Period Spring - Spring	**Average Change in Groundwater Elevation (feet)**	**Estimated Change in Storage in TAF**	
		Assuming Specific Yield = 0.07	**Assuming Specific Yield = 0.17**
2005-2006	2.3	503	1,222
2006-2007	-4.3	-929	-2,255
2007-2008	0.1	15	36
2008-2009	-1.8	-378	-918
2009-2010	0.5	102	249
2005-2010 (total)	-3.2	-686	-1,666

Note: Changes in groundwater elevation and storage are calculated for reporting area only.

Table SR-17 Groundwater Management Plans in the Sacramento River Hydrologic Region

Map Label	Agency Name	Date	County	Basin Number	Basin Name
SR-1	**Anderson-Cottonwood Irrigation District**	2006	Shasta	5-6.03	Anderson Subbasin
	No signatories on file		Tehama	5-6.04	Enterprise Subbasin
				5-6.01	Bowman Subbasin
				5-6.02	Rosewood Subbasin
SR-2	**Biggs-West Gridley Irrigation District**	1995	Butte	5-21.59	East Butte Subbasin
	No signatories on file			5-21.62	Sutter Subbasin
SR-3	**Butte County Department of Water and Resource Conservation**	2004	Butte	5-21.57	Vina Subbasin
	No signatories on file			5-21.58	West Butte Subbasin
				5-21.59	East Butte Subbasin
				5-21.60	North Yuba Subbasin
SR-4	**Butte Water District**	1996	Butte	5-21.59	East Butte Subbasin
	No signatories on file		Sutter	5-21.62	Sutter Subbasin
SR-5	**City of Davis/UC Davis**		Yolo	5-21.67	Yolo Subbasin
	No signatories on file				
SR-6	**City of Lincoln**	2003	Placer	5-21.64	North American Subbasin
	No signatories on file				
SR-7	**City of Vacaville**	2011	Solano	5-21.66	Solano Subbasin
	No signatories on file				
SR-8	**City of Woodland**	2011		5-21.67	Yolo Subbasin
	No signatories on file				Non-B118 Basin
SR-9	**Colusa County**	2008	Colusa	5-63	Stonyford Town Area Basin
	No signatories on file			5-64	Bear Valley Basin
				5-65	Little Indian Valley Basin
				5-90	Funks Creek Basin
				5-91	Antelope Creek Basin
				5-92	Blanchard Valley Basin
				5-21.52	Colusa Subbasin
				5-21.58	West Butte Subbasin
					Non-B118 Basin
SR-10	**Dunnigan Water District**	2007	Yolo	5-21.52	Colusa Subbasin

Map Label	Agency Name	Date	County	Basin Number	Basin Name
	No signatories on file				
SR-11	**El Camino Irrigation District**	1995	Tehama	5-22.50	Red Bluff Subbasin
	No signatories on file				
SR-12	**Feather Water District**	2005	Sutter	5-21.62	Sutter Subbasin
	No signatories on file				
SR-13	**Glenn Colusa Irrigation District**	1995	Colusa	5-21.52	Colusa Subbasin
	No signatories on file		Glenn	5-21.51	Corning Subbasin
					Non-B118 Basin
SR-14	**Glenn County**	2009	Glenn	5.21.52	Colusa Subbasin
	Provident Irrigation District			5-21.58	West Butte Subbasin
	Glide Water District			5.21.51	Corning Subbasin
	Willow Creek Mutual			5.61	Chrome Town Basin
	California Water Service			5-62	Elk Creek Area Basin
	Princeton-Codora-Glenn			5-63	Stonyford Town Area Basin
	Kanawha Water District			5-88	Stony Gorge Reservoir Basin
	Glenn-Colusa Irrigation District			5-89	Squaw Flat Basin
	Orland-Artois Water District			5-90	Funks Creek Basin
	Western Canal				Non-B118 Basin
	Orland Unit Water Users Association				
SR-15	**Lake County**	2006	Lake	5-13	Upper Lake Valley Basin
	No signatories on file			5-14	Scotts Valley Basin
				5-16	High Valley Basin
				5-17	Burns Valley Basin
				5-18	Coyote Valley Basin
				5-19	Collayomi Valley Basin
				5-30	Lower Lake Valley Basin
				5-31	Long Valley Basin
				5-66	Clear Lake Cache Formation Basin
				5-94	Middle Creek Basin
				1-48	Gravelley Valley Basin
SR-16	**Maine Prairie Water District**	1995	Solano	5-21.66	Solano Subbasin
	No signatories on file				
SR-17	**Maxwell Irrigation District**	2004	Colusa	5-21.52	Colusa Subbasin

Map Label	Agency Name	Date	County	Basin Number	Basin Name
	No signatories on file				
SR-18	**Natomas Central Mutual Water Company**	2009	Sutter	5-21.64	North American Subbasin
	No signatories on file		Sacramento		
SR-19	**Orland-Artois Water District**	2002	Glenn	5-21.51	Corning Subbasin
	No signatories on file				
SR-20	**Reclamation District No. 108**	2008	Colusa	5-21.52	Colusa Subbasin
	No signatories on file		Yolo		
SR-21	**Reclamation District No.1500**	2012	Sutter	5-21.62	Sutter Subbasin
	No signatories on file				
SR-22	**Reclamation District No. 2068**	2005	Solano	5-21.66	Solano Subbasin
	No signatories on file				
SR-23	**Richvale Irrigation District**	1998	Butte	5-21.59	East Butte Subbasin
	No signatories on file				
SR-24	**Sacramento Central County Water Agency**	2006	Sacramento	5-21.65	South American Subbasin
	City of Elk Grove			5-22.16	Cosumnes Subbasin
	City of Folsom				
	City of Rancho Cordova				
	City of Sacramento				
	County of Sacramento				
SR-25	**Sacramento Groundwater Authority**	2008	Sacramento	5-21.64	North American Subbasin
	California American Water				Non-B118 Basin
	Carmichael Water District				
	Citrus Heights Water District				
	Del Paso Manor Water District				
	City of Folsom				
	Fair Oaks Water District				
	Natomas Central Mutual Water Company				
	Orange Vale Water Company				
	Rio Linda/Elverta Community Water District				
	City of Sacramento				
	Sacramento County				

Map Label	Agency Name	Date	County	Basin Number	Basin Name
	Sacramento Suburban Water District				
	San Juan Water District				
	Golden State Water Company				
SR-26	**Redding Area Water Council**	2007	Shasta	5-6.03	Anderson Subbasin
	Shasta County Water Agency			5-6.04	Enterprise Subbasin
	City of Anderson			5-6.05	Millville Subbasin
	City of Redding				
	City of Shasta Lake				
	Bella Vista Water District				
	Clear Creek Community Services District				
	Centerville Community Services District				
	Cottonwood Water District				
	Shasta Community Services District				
	Mountain Gate Community Services District				
	Keswick Community Services District				
	Jones Valley Community Services District				
	Anderson-Cottonwood Irrigation District				
SR-27	**Solano Irrigation District**	2006	Solano	5-21.66	Solano Subbasin
	No signatories on file			2-3	Suisun-Fairfield Valley Basin
					Non-B118 Basin
SR-28	**South Sutter Water District**	2009	Sutter	5-21.64	North American Subbasin
	No signatories on file		Placer		
SR-29	**Sutter County Public Works Department - Water Resources**	2012	Sutter	5-21.59	East Butte Subbasin
	No signatories on file			5-21.62	Sutter Subbasin
				5-21.64	North American Subbasin
				5-21.61	South Yuba Subbasin
SR-30	**Sutter Extension Water District**	1995	Sutter	5-21.62	Sutter Subbasin
	No signatories on file			5-21.59	East Butte
SR-31	**Tehama County Flood Control & Water Conservation District**	1996	Tehama	5-6.01	Bowman Subbasin
	No signatories on file			5-6.02	Rosewood Subbasin
				5-6.06	South Battle Creek

Map Label	Agency Name	Date	County	Basin Number	Basin Name
					Subbasin
				5-21.50	Red Bluff Subbasin
				5-21.51	Corning Subbasin
				5-21.52	Colusa Subbasin
				5-21.53	Bend Subbasin
				5-21.54	Antelope Subbasin
				5-21.55	Dye Creek Subbasin
				5-21.56	Los Molinos Subbasin
				5-21.57	Vina Subbasin
SR-32	**Western Canal Water District**	2005	Butte	5-21.59	East Butte Subbasin
	No signatories on file		Glenn	5-21.58	West Butte Subbasin
SR-33	**Western Placer County Group**	2007	Placer	5-21.64	North American Subbasin
	Placer County Water Agency				
	City of Lincoln				
	City of Roseville				
	California-American Water Company				
SR-34	**Westside Water District**	2000	Colusa	5-21.52	Colusa Subbasin
	No signatories on file				
SR-35	**Yolo County Flood Control and Water Conservation District**	2006	Yolo	5-21.67	Yolo Subbasin
	No signatories on file			5-21.68	Capay Valley Subbasin
				5-21.52	Colusa Subbasin
				5-21.66	Solano Subbasin
SR-36	**Yuba County Water Agency**	2010	Yuba	5-21.60	North Yuba Subbasin
	No signatories on file			5-21.61	South Yuba Subbasin
NL-1	**Alpine County**	2007	Alpine	6-6	Carson Valley Basin
	No signatories on file				Non-B118 Basin
NL-2	**Lassen County**	2007	Lassen	6-104	Long Valley Basin
	No signatories on file			6-2	Madeline Plains Basin
				6-3	Willow Creek Valley Basin
				6-4	Honey Lake Valley Basin
				6-94	Grasshopper Valley Basin
				6-95	Dry Valley Basin
				6-96	Eagle Lake Area Basin

Map Label	Agency Name	Date	County	Basin Number	Basin Name
				5-4	Big Valley Basin

Table SR-18 Assessment for SB 1938 GWMP Required Components, SB 1938 GWMP Voluntary Components, and Bulletin 118-03 Recommended Components

SB 1938 GWMP Required Components	Percent of plans that meet requirement
Met All Required Components and Subcomponents	46%
Basin Management Objectives	50%
BMO: Monitoring/Management Groundwater Levels	86%
BMO: Monitoring Groundwater Quality	89%
BMO: Inelastic Subsidence	82%
BMO: SW/GW Interaction & Affects to Groundwater Levels & Quality	57%
Agency Cooperation	96%
Map	79%
Map: Groundwater basin area	86%
Map: Area of local agency	89%
Map: Boundaries of other local agencies	75%
Recharge Areas (1/1/2013)	Not Assessed
Monitoring Protocols	50%
MP: Changes in groundwater levels	96%
MP: Changes in groundwater quality	86%
MP: Subsidence	93%
MP: SW/GW Interaction & Affects to Groundwater Levels & Quality	50%
SB 1938 Voluntary Components	**Percent of plans that include component**
Saline Intrusion	64%
Wellhead Protection & Recharge	71%
Groundwater Contamination	61%
Well Abandonment & Destruction	89%
Overdraft	75%
Groundwater Extraction & Replenishment	61%
Monitoring	100%
Conjunctive Use Operations	86%
Well Construction Policies	93%
Construction and Operation	39%
Regulatory Agencies	100%
Land Use	68%
Bulletin 118-03 Recommended Components	**Percent of plans that include component**
GWMP Guidance	75%

SB 1938 GWMP Required Components	Percent of plans that meet requirement
Management Area	96%
BMOs, Goals, & Actions	75%
Monitoring Plan Description	75%
IRWM Planning	68%
GWMP Implementation	82%
GWMP Evaluation	86%

Table SR-19 Factors Contributing to Successful Groundwater Management Plan Implementation in the Sacramento River Hydrologic Region

Key components	Respondents
Data collection and sharing	10
Outreach and education	9
Developing an understanding of common interest	9
Sharing of ideas and information with other water resource managers	11
Broad stakeholder participation	9
Adequate surface water supplies	10
Adequate regional and local surface storage and conveyance systems	10
Water budget	6
Funding	6
Time	6

Table SR-20 Factors Limiting Successful Groundwater Management Plan Implementation in the Sacramento River Hydrologic Region

Limiting Factors	Respondents
Funding for groundwater management projects	6
Funding for groundwater management planning	6
Unregulated Pumping	3
Groundwater Supply	-
Participation across a broad distribution of interests	1
Lack of Governance	-
Surface storage and conveyance capacity	1
Understanding of the local issues	3
Access to planning tools	3
Outreach and education	2
Data collection and sharing	1
Funding to assist in stakeholder participation	5

Table SR-21 Groundwater Ordinances that Apply to Counties in the Sacramento River Hydrologic Region

County	Groundwater Management	Guidance Committees	Export Permits	Recharge	Well Abandonment & Destruction	Well Construction Policies
Alpine	-	-	Y	-	Y	Y
Amador	-	-	-	-	Y	Y
Butte	Y	Y	Y	-	Y	Y
Colusa	-	-	Y	-	-	Y
El Dorado	-	-	-	-	Y	Y
Glenn	Y	Y	-	-	Y	Y
Lake	-	-	Y	-	Y	Y
Lassen	Y	Y	Y	-	Y	-
Modoc	-	-	Y	-	-	Y
Napa	-	-	-	-	Y	Y
Nevada	-	-	-	-	Y	Y
Placer	-	-	-	-	Y	Y
Plumas	-	-	-	-	Y	Y
Sacramento	-	-	Y	-	Y	Y
Shasta	-	-	Y	-	-	-
Sierra	-	-	Y	-	-	-
Siskiyou	-	Y	Y	-	Y	-
Solano	-	-	-	-	Y	Y
Sutter	-	-	-	-	Y	Y
Tehama	-	-	Y	-	Y	Y
Yolo	-	-	Y	-	-	-
Yuba	-	-	-	-	Y	Y

Table SR-22 NMFS Recovery Priorities for Selected Water Bodies in Sacramento Valley

Water Body	NMFS Recovery Priorities (Species – Recovery Priority)	NMFS Reintroduction Priorities (Species – Recovery Priority)
McCloud River		Winter-run Chinook Salmon – Primary Spring-run Chinook Salmon – Primary Central Valley Steelhead – Primary (Dependent on successful passage programs above Keswick and Shasta Dams)
Little Sacramento River (above Shasta Dam)		Winter-run Chinook Salmon – Primary Spring-run Chinook Salmon – Primary Central Valley Steelhead – Primary (Dependent on successful passage programs above Keswick and Shasta Dams)
Clear Creek	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	
Cottonwood Creek	Spring-run Chinook Salmon – Core 2 Central Valley Steelhead – Core 2	
Cow Creek	Central Valley Steelhead – Core 2	
Antelope Creek	Spring-run Chinook Salmon – Core 2 Central Valley Steelhead – Core 1	
Battle Creek	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	Winter-run Chinook Salmon – Primary
Big Chico Creek	Spring-run Chinook Salmon – Core 3 Central Valley Steelhead – Core 1	
Bear River (Tributary to the Feather River)	Spring-run Chinook Salmon – Core 3 Central Valley Steelhead – Core 3	
Lower Butte Creek	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 2	
Mill Creek	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	
Deer Creek	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	
Lower Feather River	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	
American River	Central Valley Steelhead – Core 2	Upper America River Spring-run Chinook Salmon – Second Central Valley Steelhead – Primary
Tuba River	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	

Source:

Table SR-23 Conceptual Growth Scenarios

Scenario	Population Growth	Development Density
LOP-HID	Lower than Current Trends	Higher than Current Trends
LOP-CTD	Lower than Current Trend	Current Trends
LOP-LOD	Lower than Current Trends)	Lower than Current Trends
CTP-HID	Current Trends	Higher than Current Trends
CTP-CTD	Current Trends	Current Trends
CTP-LOD	Current Trends	Lower than Current Trends
HIP-HID	Higher than Current Trends	Higher than Current Trends
HIP-CTD	Higher than Current Trends	Current Trends
HIP-LOD	Higher than Current Trends	Lower than Current Trends

Source: California Department of Water Resources 2012.

Table SR-24 Growth Scenarios (Urban) — Sacramento River

Scenario[a]	2050 Population (thousand)	Population Change (thousand) 2006[b] to 2050	Development Density	2050 Urban Footprint (thousand acres)	Urban Footprint Increase (thousand acres) 2006[c] to 2050
LOP-HID	3,894.6[d]	1,010.2	High	807.1	109.5
LOP-CTD	3,894.6	1,010.2	Current Trends	823.4	125.8
LOP-LOD	3,894.6	1,010.2	Low	839.5	141.9
CTP-HID	4,486.2[e]	1,601.8	High	882.9	185.3
CTP-CTD	4,486.2	1,601.8	Current Trends	906.6	209.0
CTP-LOD	4,486.2	1,601.8	Low	930.2	232.6
HIP-HID	5,892.6[f]	3,008.2	High	1,007.8	310.2
HIP-CTD	5,892.6	3,008.2	Current Trends	1,053.4	355.8
HIP-LOD	5,892.6	3,008.2	Low	1,098.1	400.5

Source: California Department of Water Resources 2012.

Notes:

[a] See Table SR-23 for scenario definitions

[b] 2006 population was 2,884.4 thousand.

[C] 2006 urban footprint was 697.6 thousand acres.

[d] Values modified by the California Department of Water Resources (DWR) from the Public Policy Institute of California.

[e] Values provided by the California Department of Finance.

[f] Values modified by DWR from the Public Policy Institute of California.

Table SR-25 Growth Scenarios (Agriculture) — Sacramento River

Scenario[a]	2050 Irrigated Land Area[b] (thousand acres)	2050 Irrigated Crop Area[c] (thousand acres)	2050 Multiple Crop Area[d] (thousand acres)	Change in Irrigated Crop Area (thousand acres) 2006 to 2050
LOP-HID	1880.6	1895.1	14.5	-4.8
LOP-CTD	1876.6	1891.1	14.5	-8.9
LOP-LOD	1872.8	1887.2	14.4	-12.7
CTP-HID	1859.3	1873.6	14.3	-26.3
CTP-CTD	1853.3	1867.6	14.3	--32.3
CTP-LOD	1846.9	1861.1	14.2	-38.8
HIP-HID	1825.7	1839.8	14.1	-60.1
HIP-CTD	1813.2	1827.2	14.0	-72.7
HIP-LOD	1800.6	1814.5	13.9	-85.4

Source: California Department of Water Resources 2012.

Notes:

a See Table SR-23 for scenario definitions

b 2006 Irrigated land area was estimated by the California Department of Water Resources (DWR) to be 1879.6 thousand acres.

c 2006 Irrigated crop area was estimated by DWR to be 1899.9 thousand acres.

d 2006 multiple crop area was estimated by DWR to be 20.3 thousand acres.

Table SR-26 Resource Management Strategies Addressed in IRWMPs in the Sacramento River Hydrologic Region

Resource Management Strategy	IRWMP 1	IRWMP 2
Agricultural Water Use Efficiency		
Urban Water Use Efficiency		
Conveyance – Delta		
Conveyance – Regional/Local		
System Reoperation		
Water Transfers		
Conjunctive Management & Groundwater		
Desalination		
Precipitation Enhancement		
Recycled Municipal Water		
Surface Storage – CALFED		
Surface Storage – Regional/Local		
Drinking Water Treatment and Distribution		
Groundwater and Aquifer Remediation		
Match Water Quality to Use		
Pollution Prevention		
Salt and Salinity Management		
Agricultural Lands Stewardship		
Economic Incentives		
Ecosystem Restoration		
Forest Management		
Land Use Planning and Management		
Recharge Areas Protection		
Water-Dependent Recreation		
Watershed Management		
Flood Risk Management		
Flood Management		
Desalination (Brackish and Sea Water)		
Salt and Salinity Management		

Figure SR-1 Sacramento River Hydrologic Region

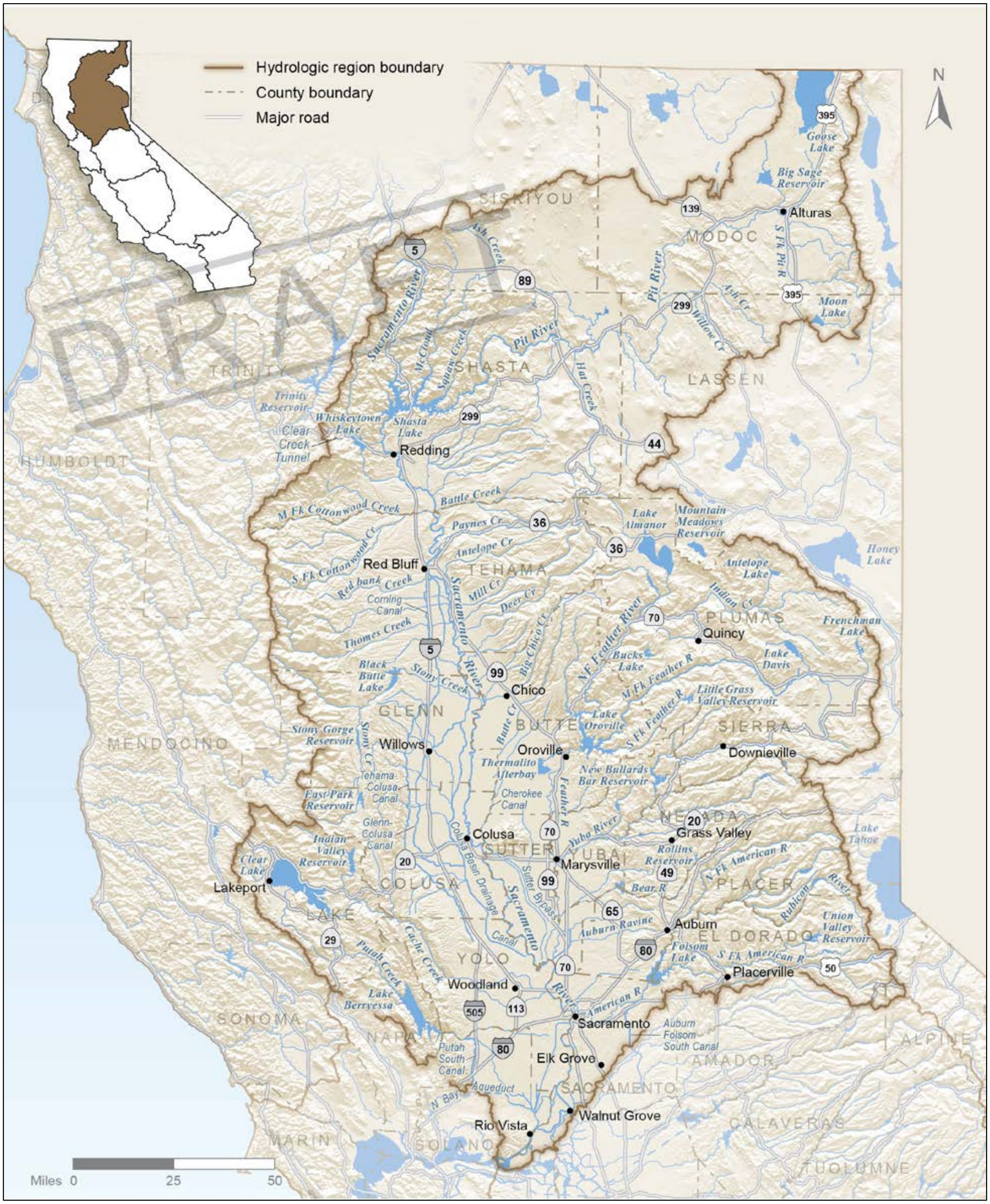


Figure SR-2 Sacramento River Hydrologic Region Watersheds

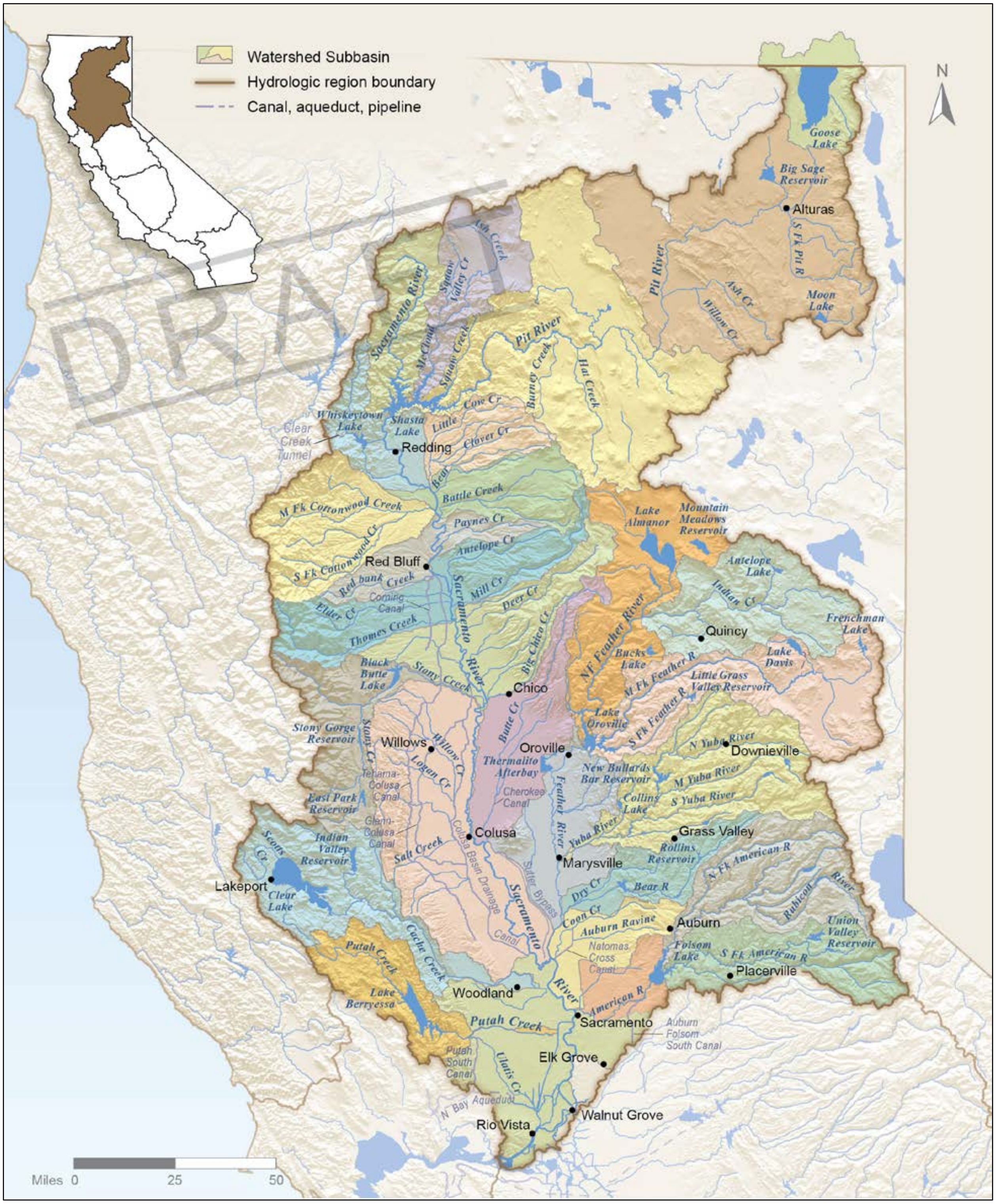


Figure SR-3 Alluvial Groundwater Basins and Subbasins within the Sacramento River Hydrologic Region

Source: Department of Water Resources, CWP 2013

Figure SR-4 Number of Well Logs by County and Use for the Sacramento River Hydrologic Region (1977–2010)

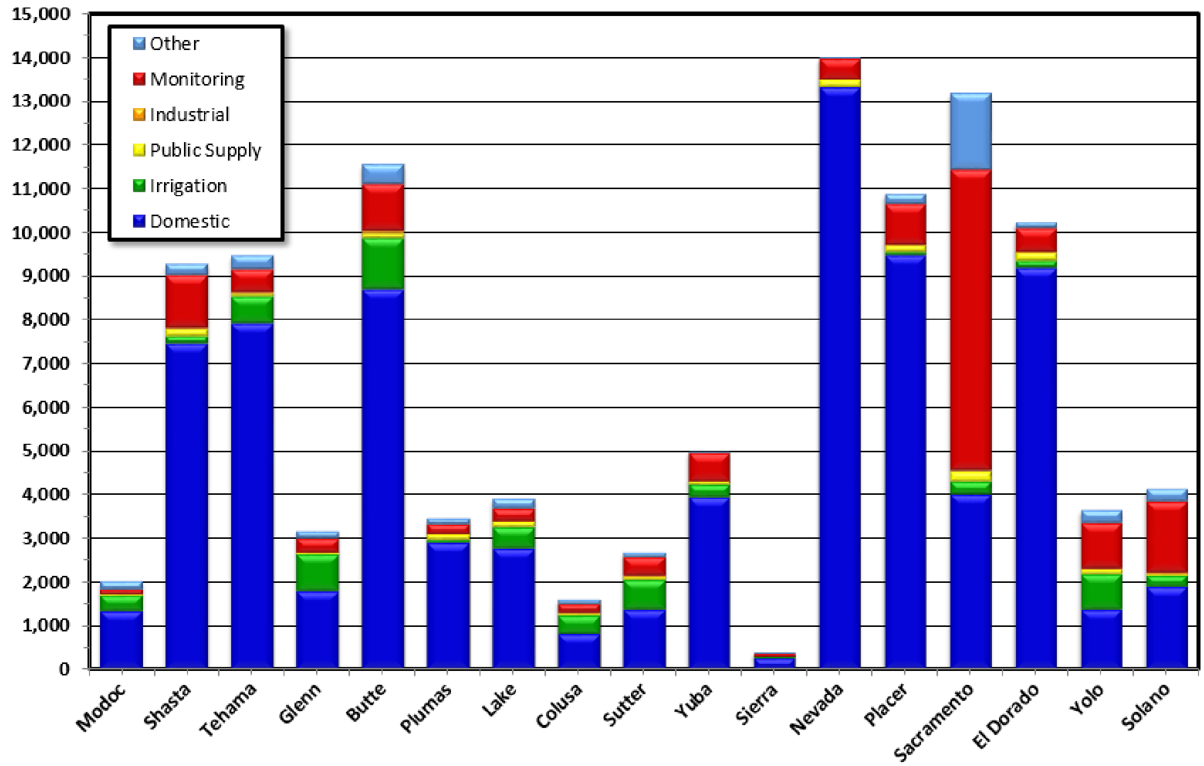


Figure SR-5 Percentage of Well Logs by Use for the Sacramento River Hydrologic Region (1977–2010)

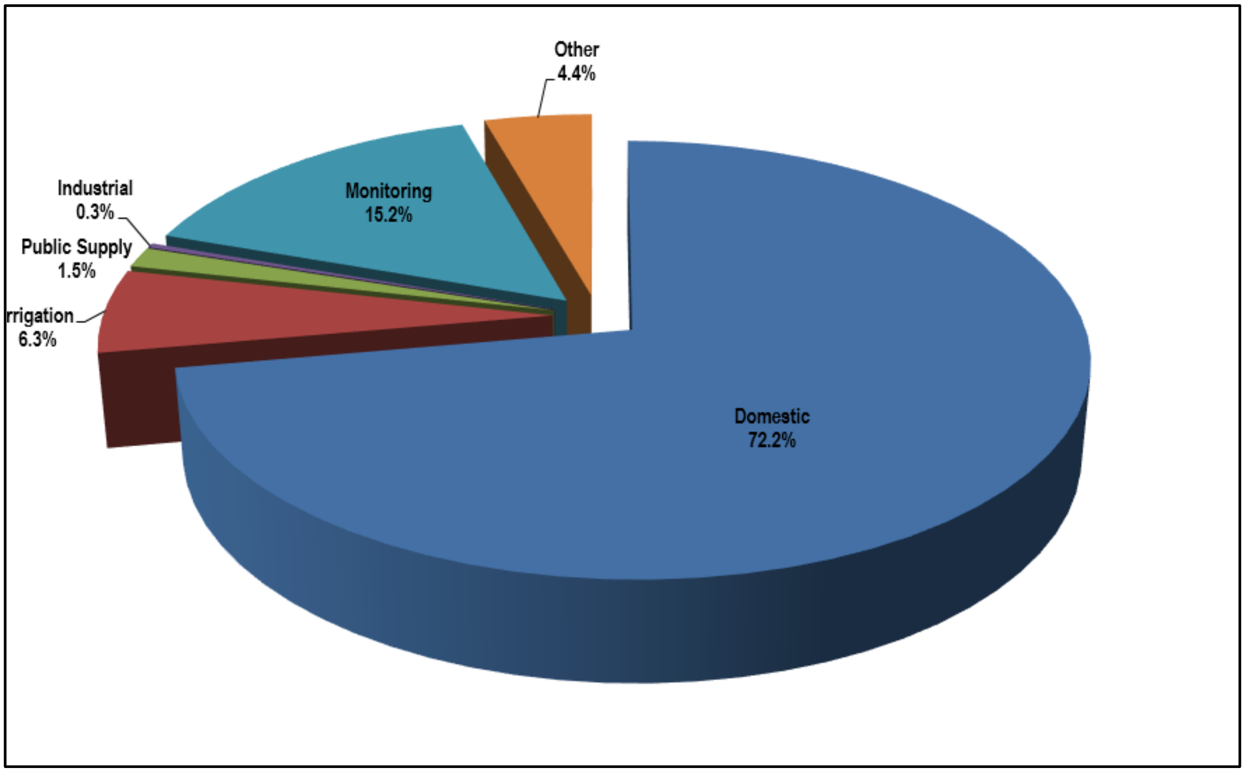


Figure SR-6 Number of Well Logs Filed per Year by Use for the Sacramento River Hydrologic Region (1977–2010)

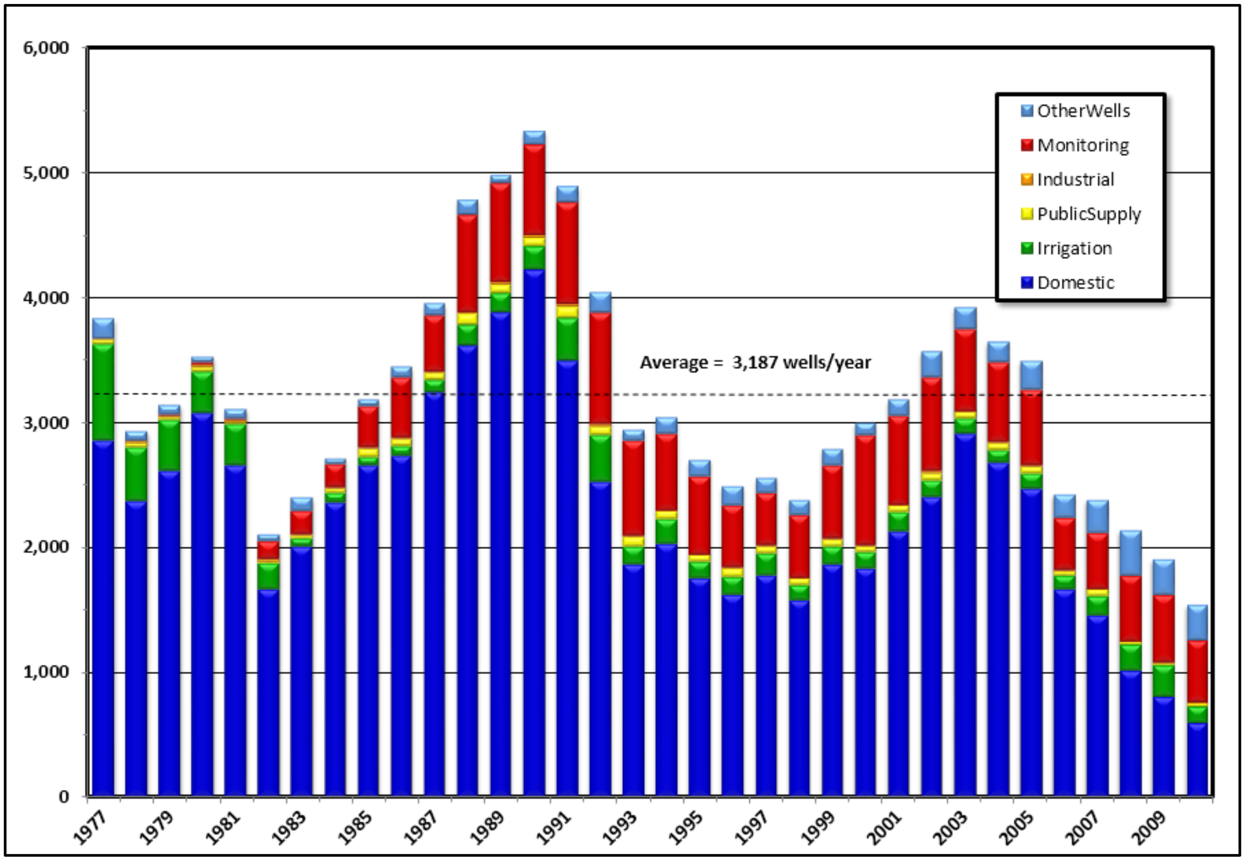


Figure SR-7 CASGEM Groundwater Basin Prioritization for the Sacramento River Hydrologic Region

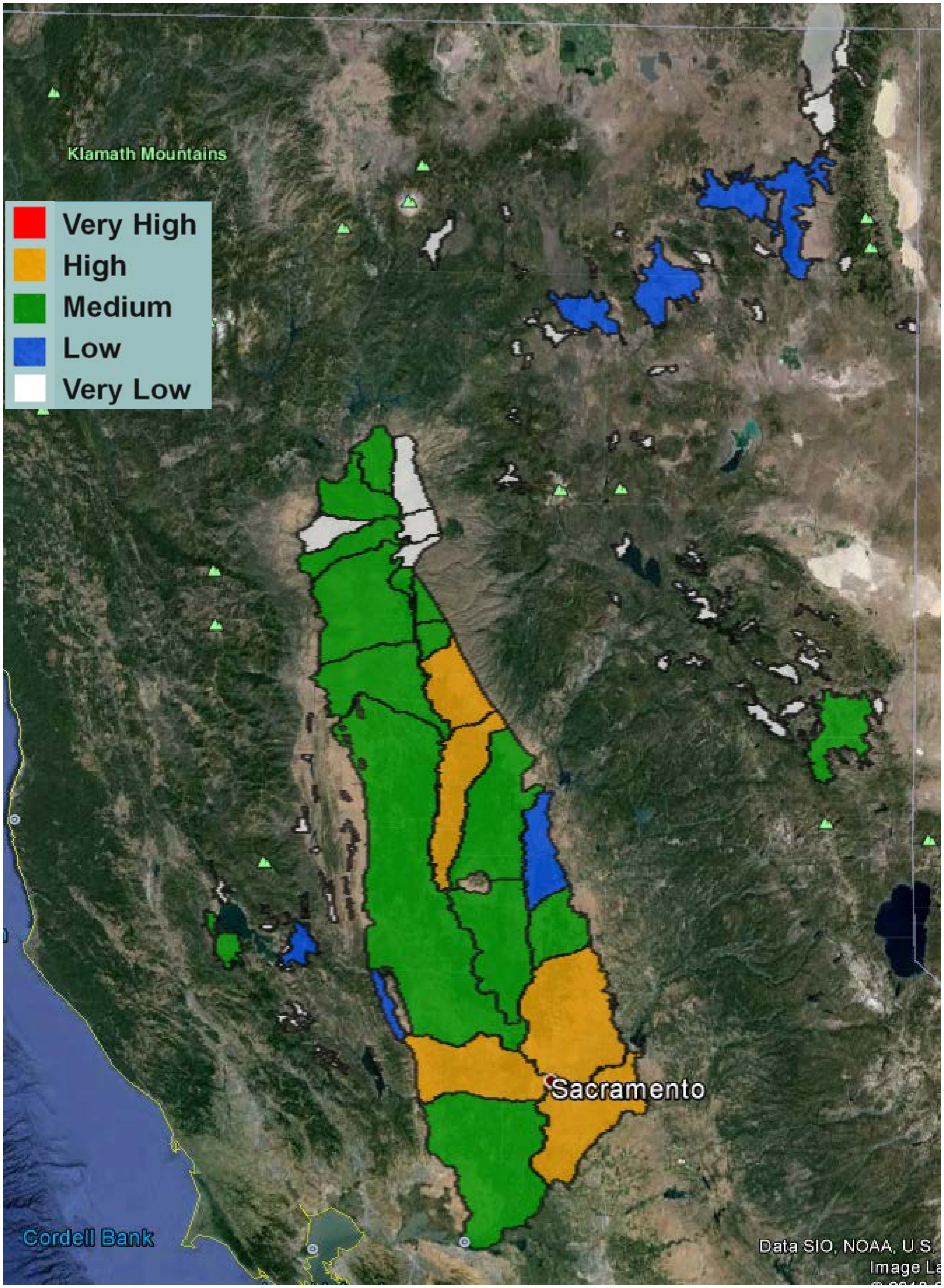
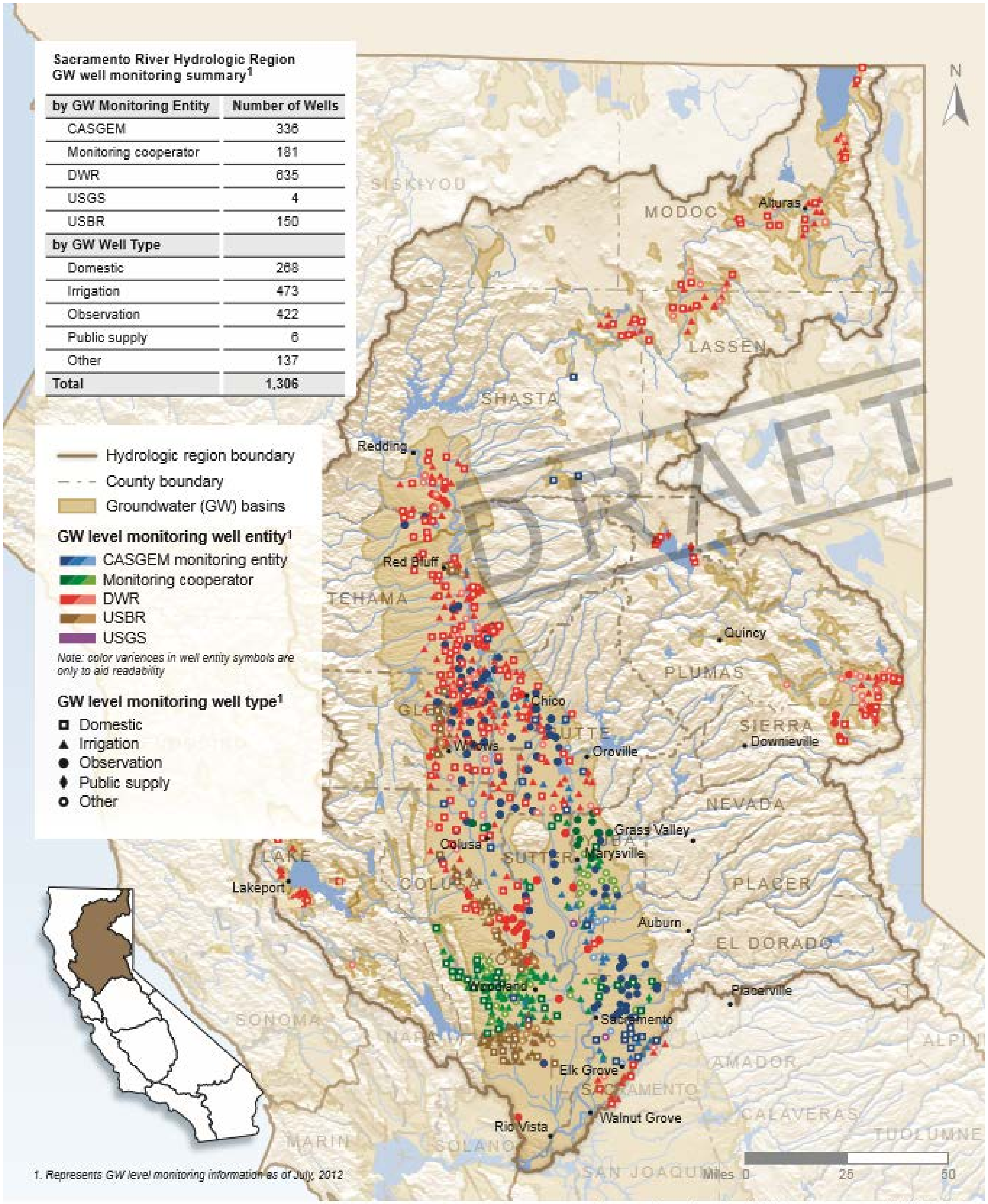


Figure SR-8 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity in the Sacramento River Hydrologic Region



Source: Department of Water Resources, CWP 2013

Figure SR-9 Percentage of Monitoring Wells by Use in the Sacramento River Hydrologic Region

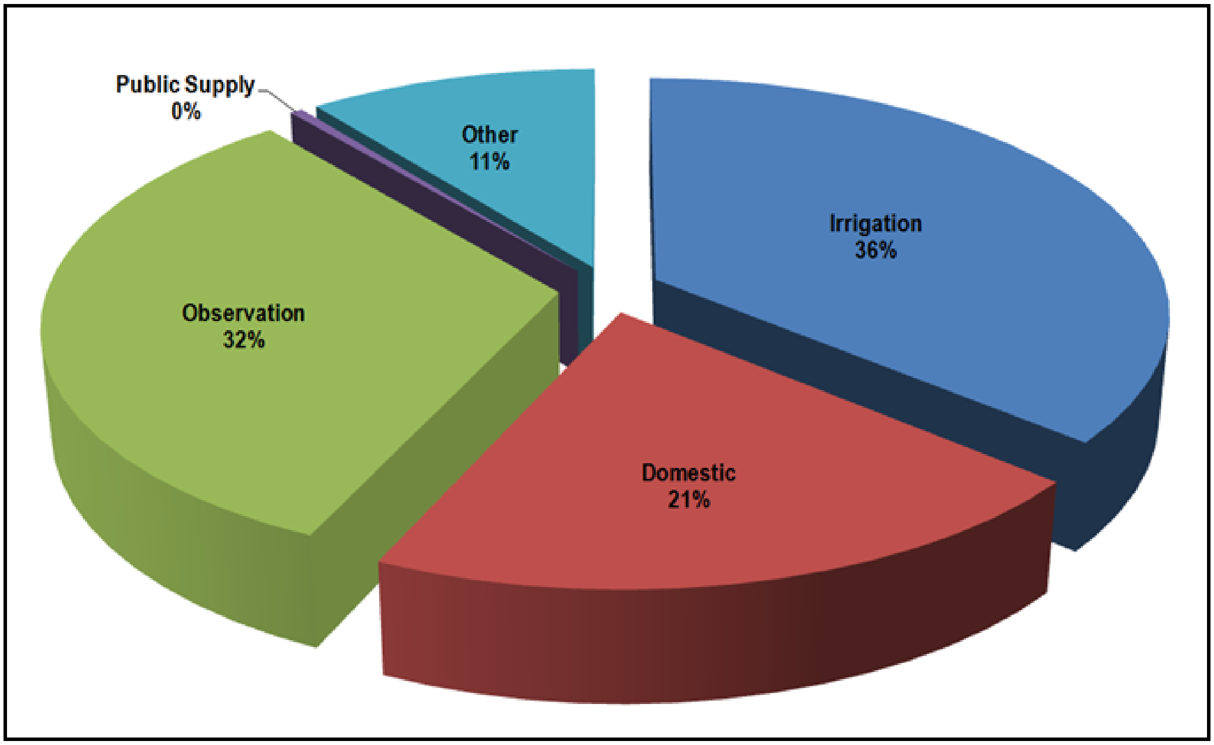


Figure SR-10 Sacramento River Regional Inflows and Outflows in 2010

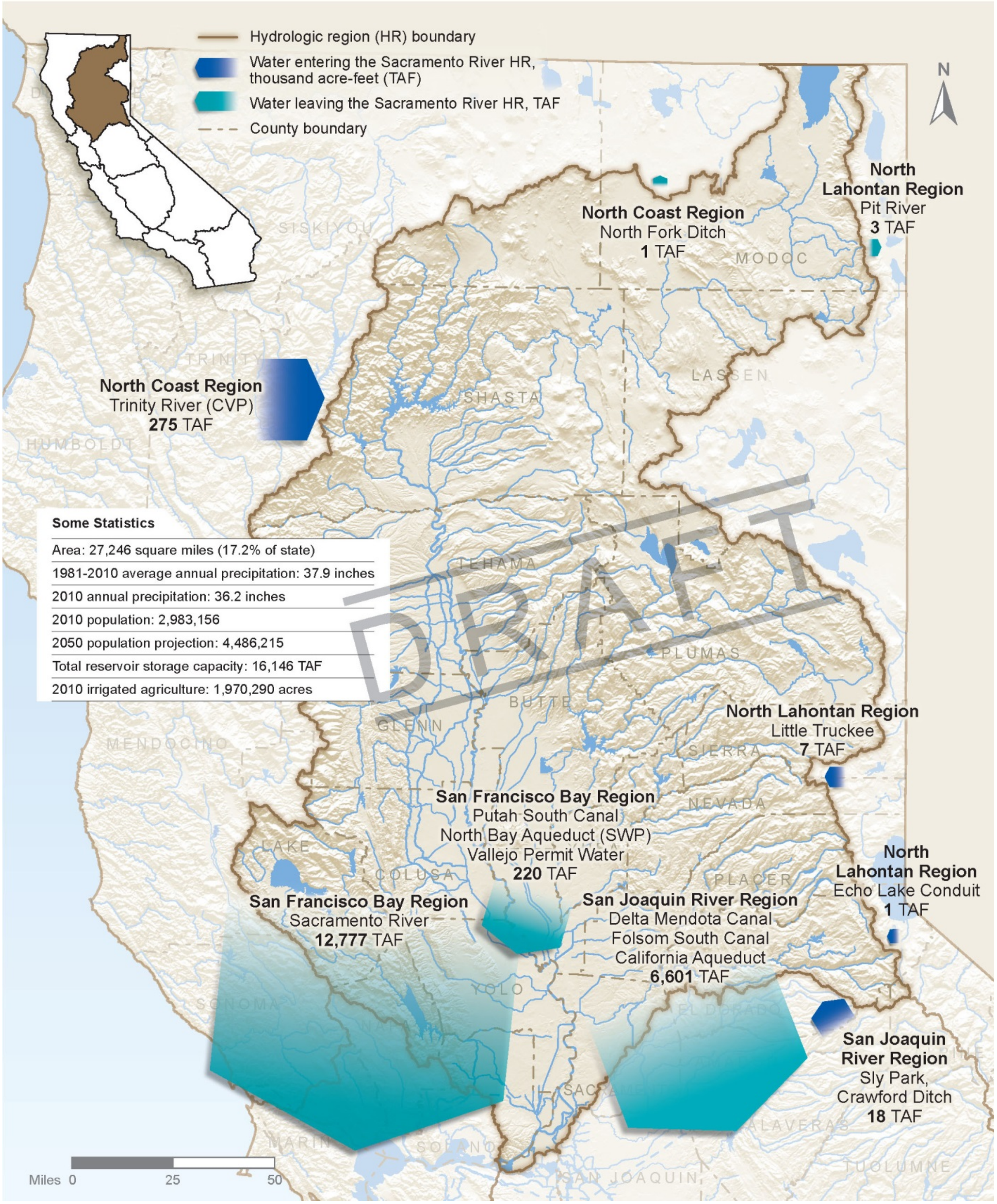
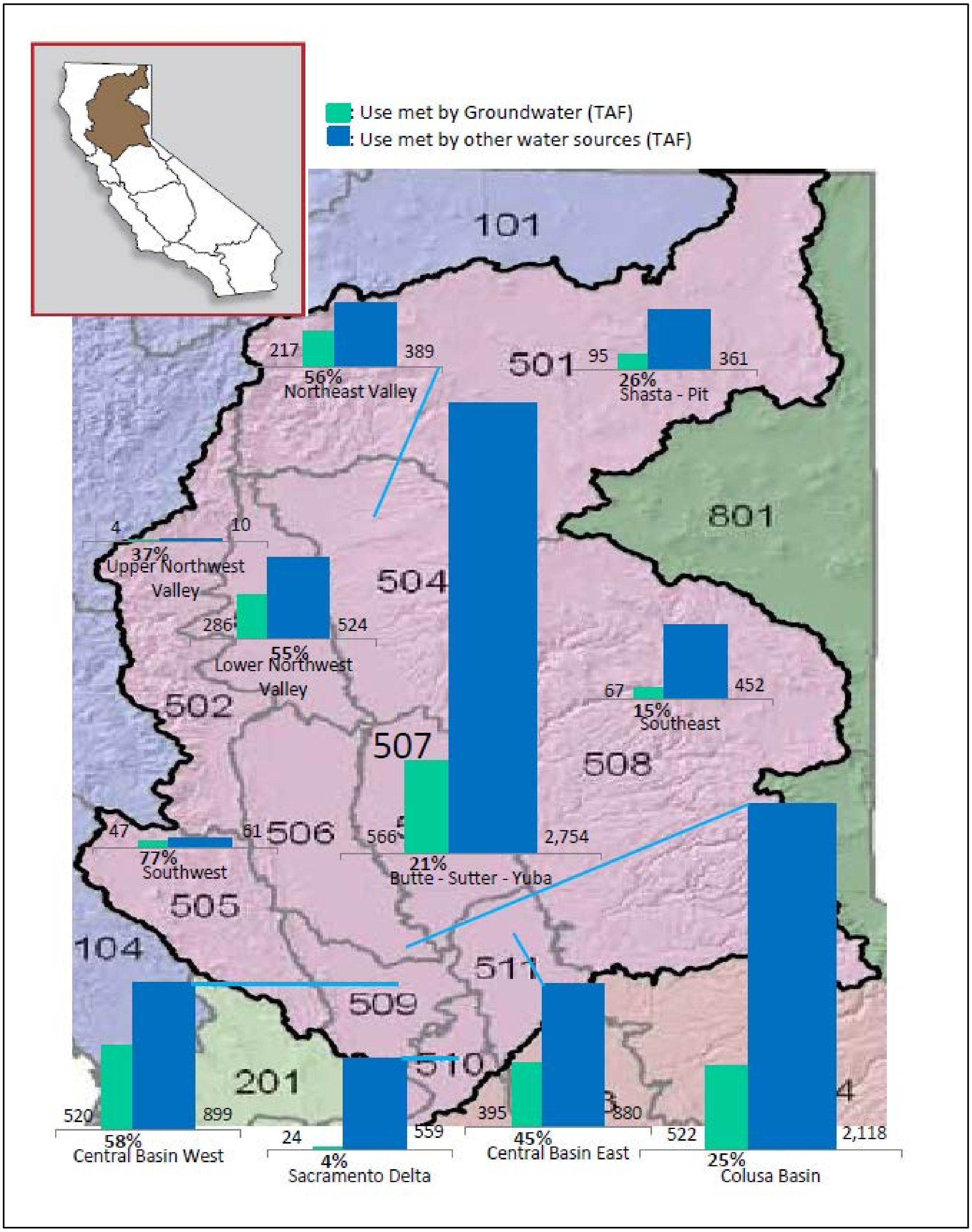
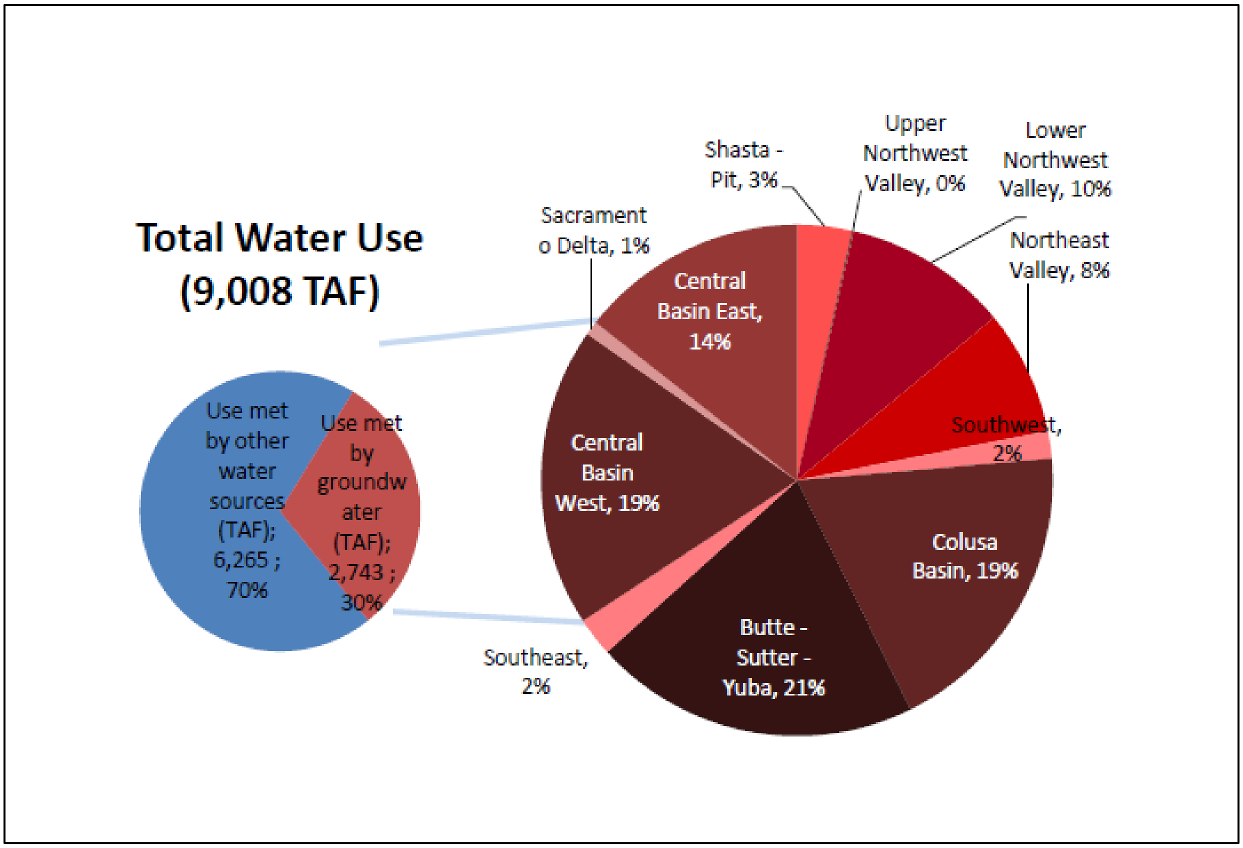


Figure SR-11 Contribution of Groundwater to the Sacramento River Hydrologic Region Water Supply by Planning Area (2005-2010)





Total Water Use
(9,008 TAF)
Use met by other water sources (TAF); 6,265 ; 70%
Use met by groundwater (TAF); 2,743 ; 30%
Shasta - Pit, 3%
Upper Northwest Valley, 0%
Lower Northwest Valley, 10%
Northeast Valley, 8%
Sacramento Delta, 1%
Central Basin East, 14%
Central Basin West, 19%
Southwest, 2%
Colusa Basin, 19%
Butte - Sutter - Yuba, 21%
Southeast, 2%

Figure SR-12 Sacramento River Hydrologic Region Annual Groundwater Water Supply Trend (2002-2010)

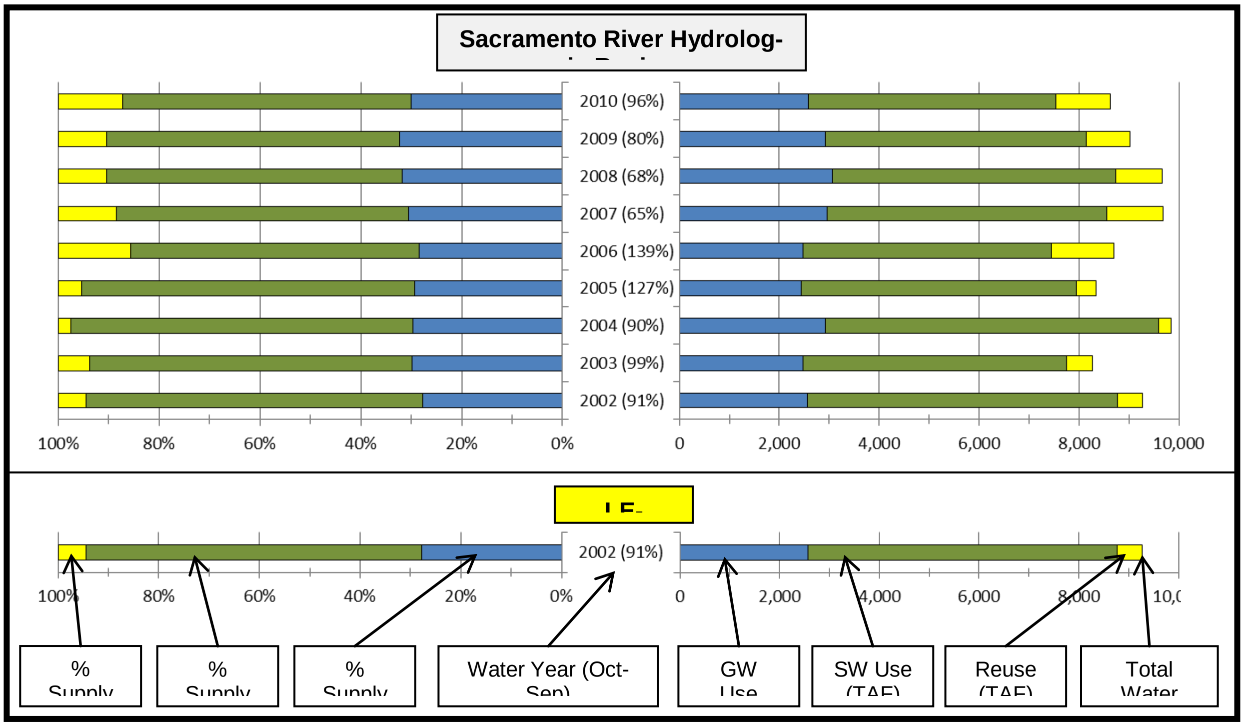


Figure SR-13 Sacramento River Hydrologic Region Annual Groundwater Supply Trend by Type of Use (2002-2010)

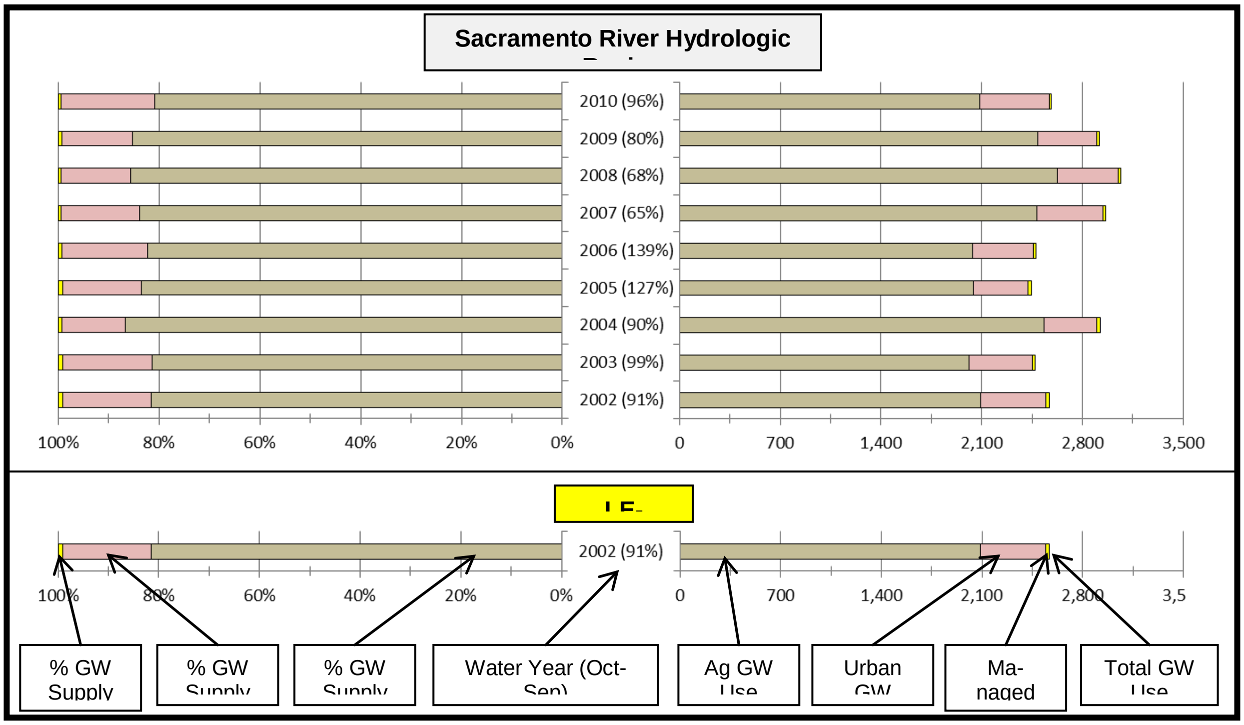
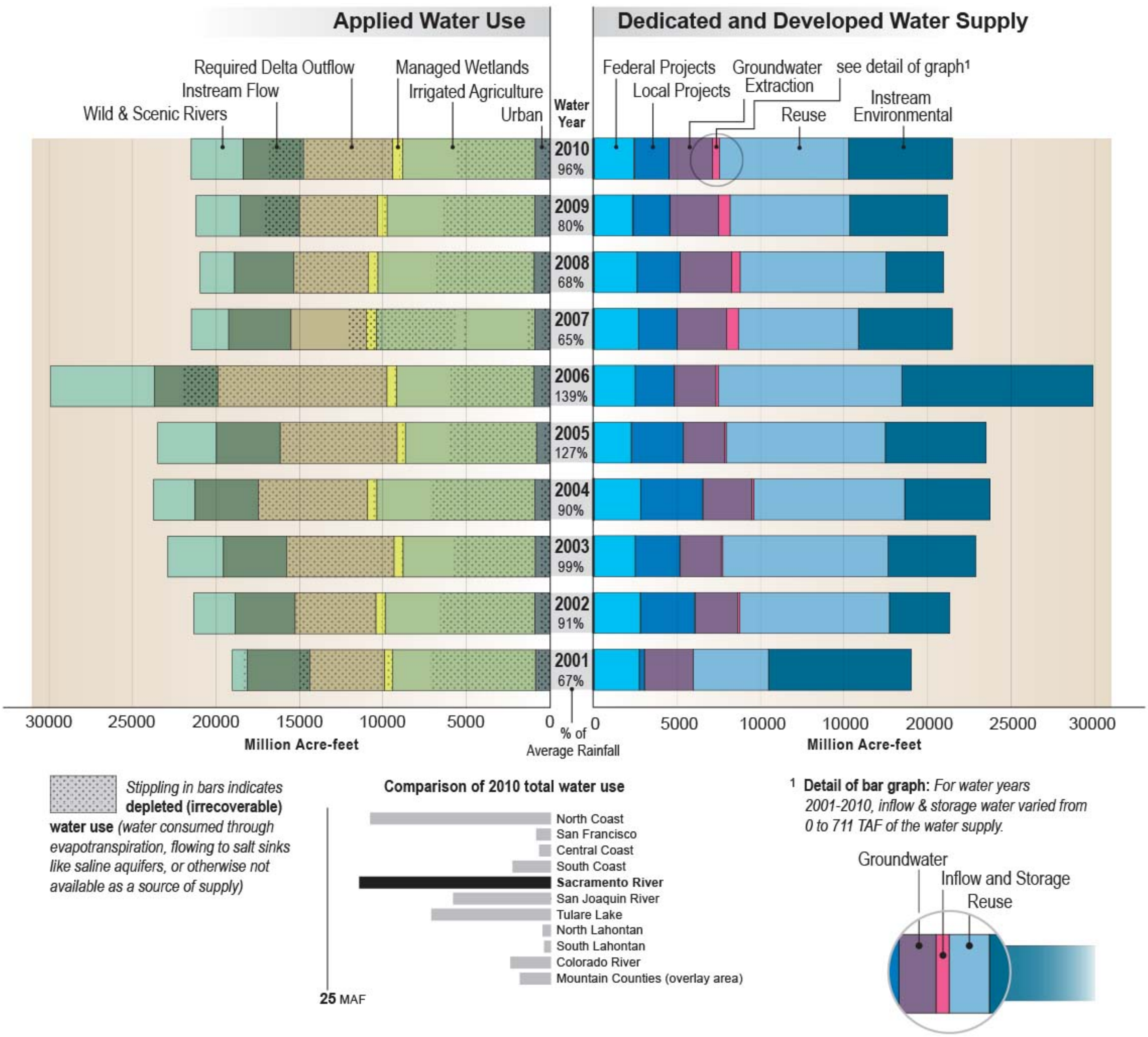


Figure SR-14 Sacramento River Hydrologic Region Water Balance by Water Year, 2001-2010

California's water resources vary significantly from year to year. Ten recent years show this variability for water use and water supply. Applied Water Use shows how water is applied to urban and agricultural sectors and dedicated to the environment and the Dedicated and Developed Water Supply shows where the water came from each year to meet those uses. Dedicated and Developed Water Supply does not include the approximately 125 million acre-feet (MAF) of statewide precipitation and inflow in an average year that either evaporates, are used by native vegetation, provides rainfall for agriculture and managed wetlands, or flow out of the state or to salt sinks like saline aquifers. Groundwater extraction includes annually about 2 MAF more groundwater used statewide than what naturally recharges – called groundwater overdraft. Overdraft is characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years.



Key Water Supply and Water Use Definitions

Applied water. The total amount of water that is diverted from any source to meet the demands of water users without adjusting for water that is depleted, returned to the developed supply or considered irrecoverable (see water balance figure).

Consumptive use is the amount of applied water used and no longer available as a source of supply. Applied water is greater than consumptive use because it includes consumptive use, reuse, and outflows.

Instream environmental. Instream flows used only for environmental purposes.

Instream flow. The use of water within its natural watercourse as specified in an agreement, water rights permit, court order, FERC license, etc.

Groundwater Extraction. An annual estimate of water withdrawn from banked, adjudicated, and unadjudicated groundwater basins.

Recycled water. Municipal water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource.

Reused water. The application of previously used water to meet a beneficial use, whether treated or not prior to the subsequent use.

Urban water use. The use of water for urban purposes, including residential, commercial, industrial, recreation, energy production, military, and institutional classes. The term is applied in the sense that it is a kind of use rather than a place of use.

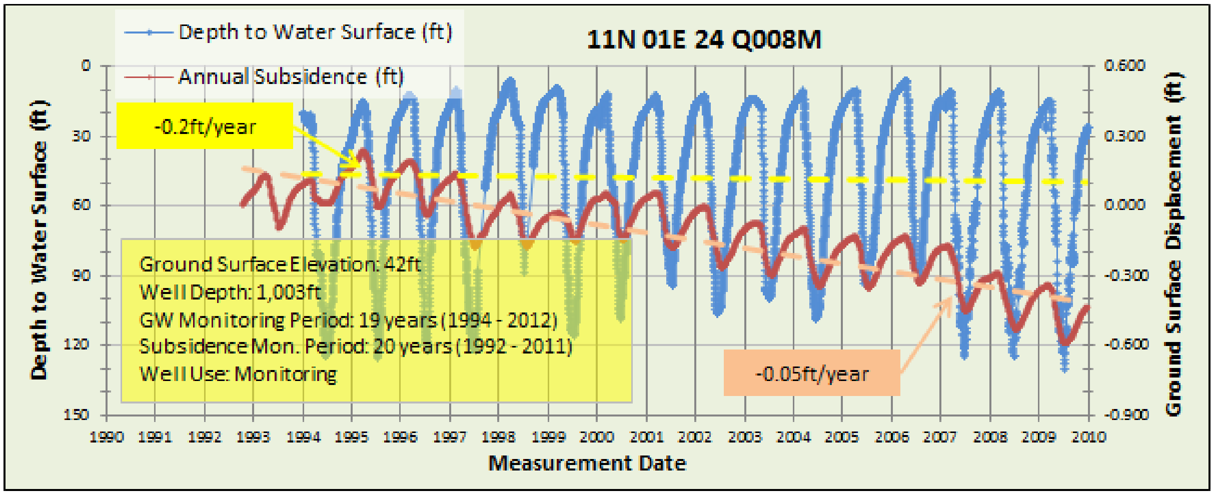
Water balance. An analysis of the total developed/dedicated supplies, uses, and operational characteristics for a region. It shows what water was applied to actual uses so that use equals supply.

Sacramento River Water Balance by Water Year Data Table (MAF)

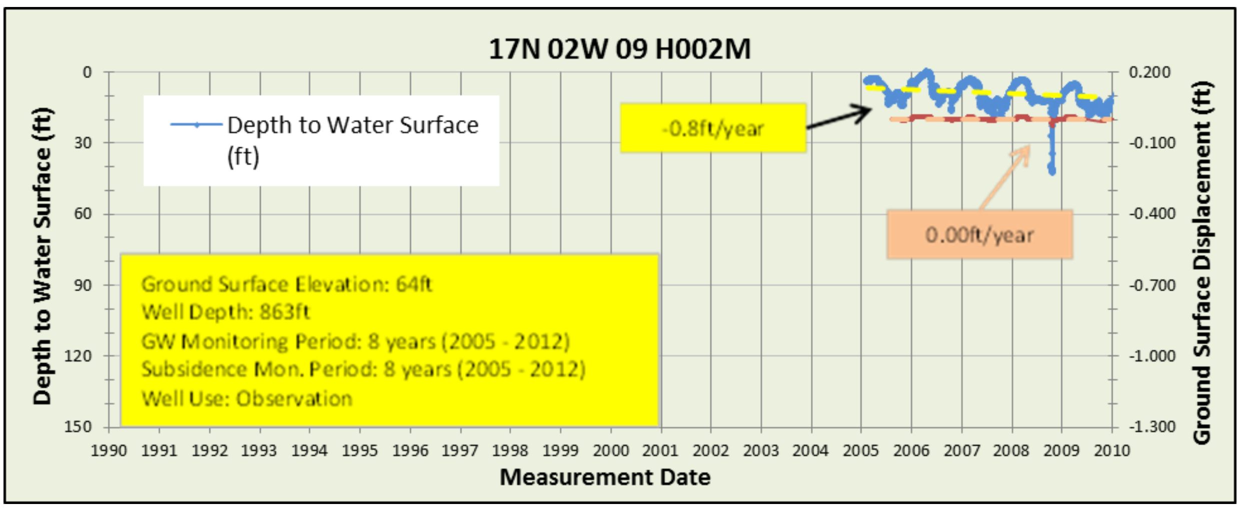
	2001 (67%)	2002 (91%)	2003 (99%)	2004 (90%)	2005 (127%)	2006 (139%)	2007 (65%)	2008 (68%)	2009 (80%)	2010 (96%)
Applied Water Use										
Urban	877	911	890	918	816	958	914	953	914	889
Irrigated Agriculture	8,567	8,964	7,914	9,455	7,852	8,241	9,497	9,357	8,847	7,942
Managed Wetlands	469	555	540	557	499	571	606	580	574	602
Req Delta Outflow	4,486	4,843	6,424	6,532	6,999	10,128	4,501	4,464	4,680	5,323
Instream Flow	3,748	3,590	3,795	3,797	3,815	3,801	3,730	3,541	3,532	3,622
Wild & Scenic R.	885	2,475	3,331	2,489	3,530	6,216	2,239	2,068	2,656	3,121
Total Uses	**19,032**	**21,338**	**22,894**	**23,749**	**23,512**	**29,913**	**21,486**	**20,963**	**21,203**	**21,500**
Depleted Water Use (stippling)										
Urban	770	606	572	539	405	515	488	532	505	491
Irrigated Agriculture	6,302	5,691	4,923	6,237	5,262	5,001	5,906	5,872	5,500	4,723
Managed Wetlands	378	226	176	239	192	200	239	229	222	222
Req Delta Outflow	4,486	4,843	6,424	6,532	6,999	10,128	4,501	4,464	4,680	5,323
Instream Flow	614	0	7	7	6	2,065	2,038	0	2,065	2,065
Wild & Scenic R.	321	0	0	0	0	0	0	0	0	0
Total Uses	**12,871**	**11,365**	**12,101**	**13,554**	**12,864**	**17,909**	**13,171**	**11,098**	**12,972**	**12,824**
Dedicated and Developed Water Supply										
Instream	8554	3621	5255	5119	6038	11451	5622	3450	5856	6233
Local Projects	289	3,244	2,664	3,694	3,102	2,342	2,293	2,565	2,185	2,063
Local Imported Deliveries	9	11	8	15	6	9	10	9	10	8
Colorado Project	0	0	0	2	0	0	0	0	0	0
Federal Projects	2,737	2,800	2,494	2,817	2,257	2,495	2,694	2,606	2,333	2,426
State Project	20	20	4	25	25	4	9	13	46	33
Groundwater Extraction	2,927	2,570	2,473	2,924	2,446	2,478	2,961	3,069	2,919	2,585
Inflow & Storage	0	121	104	117	111	143	711	517	686	429
Reuse & Seepage	4,497	8,952	9,893	9,037	9,527	10,992	7,187	8,734	7,168	7,724
Recycled Water	0	0	0	0	0	0	0	0	0	0
Total Supplies	**19,032**	**21,338**	**22,894**	**23,749**	**23,512**	**29,913**	**21,486**	**20,963**	**21,203**	**21,500**

Figure SR-15 Selected Subsidence and Groundwater Level Hydrographs for the Sacramento River Hydrologic Region

A: Hydrograph 11N01E24Q008M



B: Hydrograph 17N02W09H002M



C: Hydrograph 22N02W15C002M

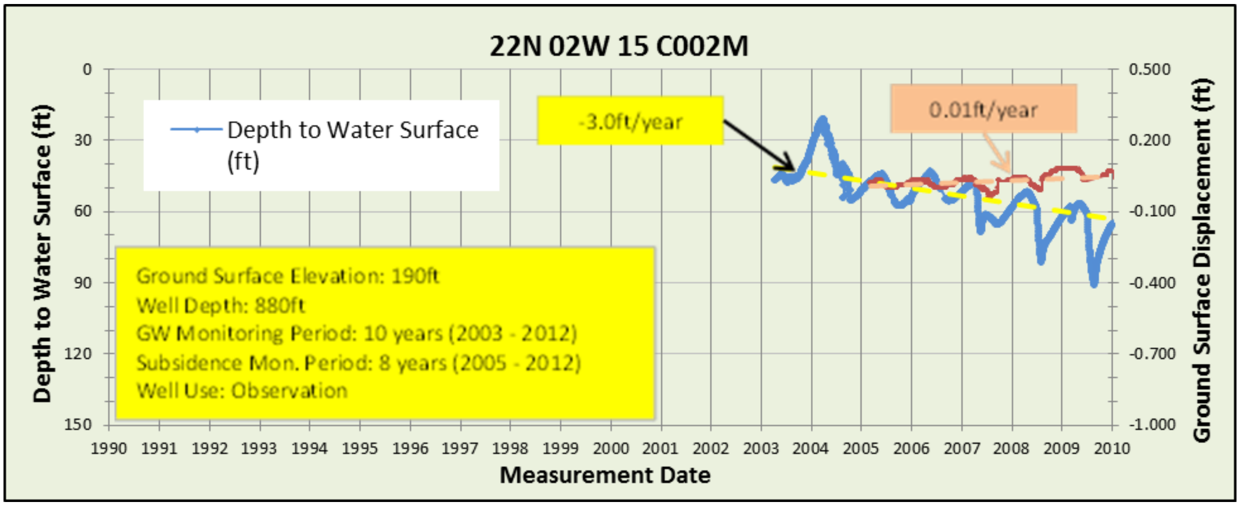
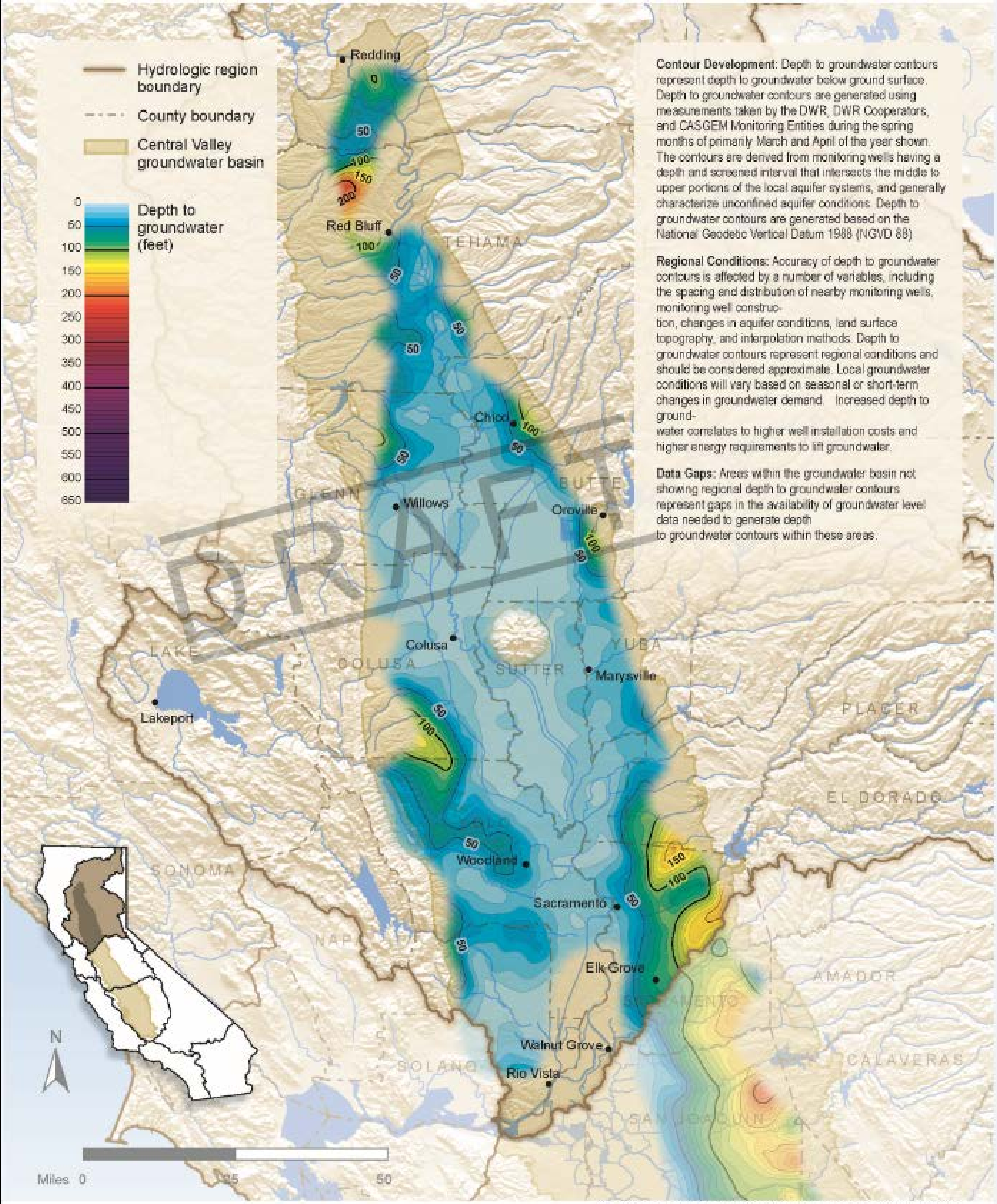


Figure SR-16 Spring 2010 Depth to Groundwater Contours for the Sacramento River Hydrologic Region



Source: Department of Water Resources, CWP 2013

Figure SR-17 Spring 2010 Groundwater Elevation Contours for the Sacramento River Hydrologic Region

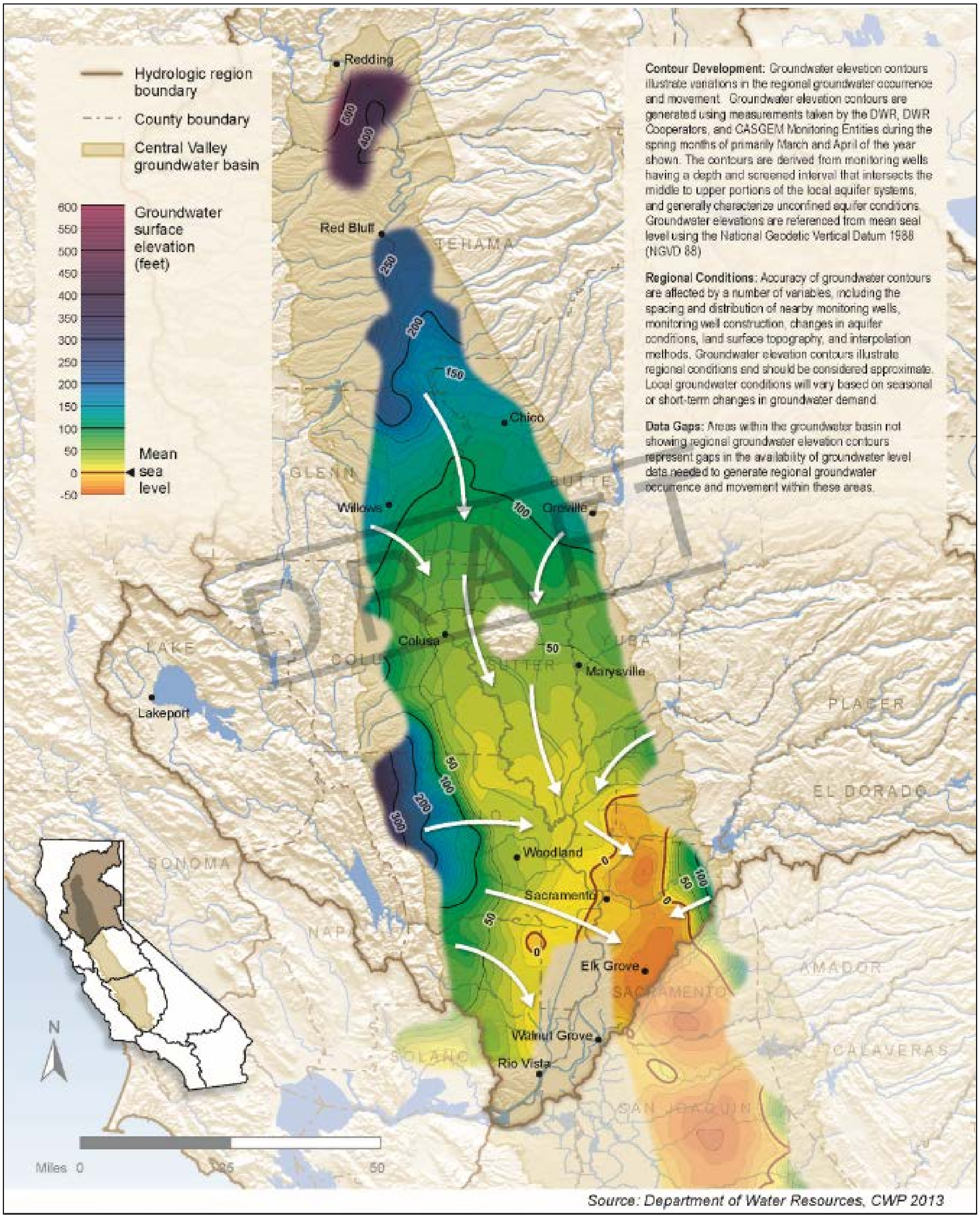


Figure SR-18 Groundwater Level Trends in Selected Wells in the Sacramento River Hydrologic Region

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.

Regional locator map

(A) Hydrograph 38N07E23E001M: shows a well with long term declining groundwater levels. The increasing seasonal fluctuations indicate increased groundwater use in the recent years.

(B) Hydrograph 24N02W24D002-4M: demonstrates the potentiometric head increasing with depth. This indicates there is an upward gradient to groundwater flow, characterizing this location as a potential groundwater discharge versus recharge area.

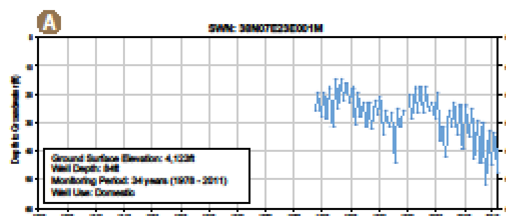
(C) Hydrograph 23N03W13C003-7M: demonstrates the potentiometric head decreasing with depth. This indicates there is a downward gradient to groundwater flow, characterizing this location as a potential groundwater recharge area.

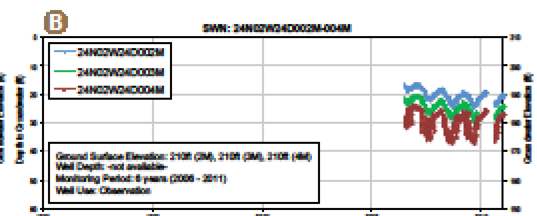
(D) Hydrograph 21N03W33A004M: shows declining groundwater levels during the 1970's, prior to bringing in surface water through the Tehama-Colusa Canal. The declines since the late 1980's is a result of drought or dry conditions and more recently significant changes in land use and irrigation methods.

(E) Hydrograph 22N01E28J003M: shows the effect dry periods have on groundwater levels in areas of heavy reliance on groundwater. During the dry periods, groundwater withdraws tend to outpace recharge resulting in declining groundwater elevation. At this well, the recovery was weak or missing following the last two dry periods.

(F) Hydrograph 14N01E14G001M: shows a very stable water table with a seasonal fluctuation of generally less than 10 feet. The land use in area is dominated by agricultural rice production that uses predominantly surface water.

(G) Hydrograph 15N04E28D001M: illustrates recovering groundwater conditions resulting from implementation of in-lieu groundwater recharge projects.

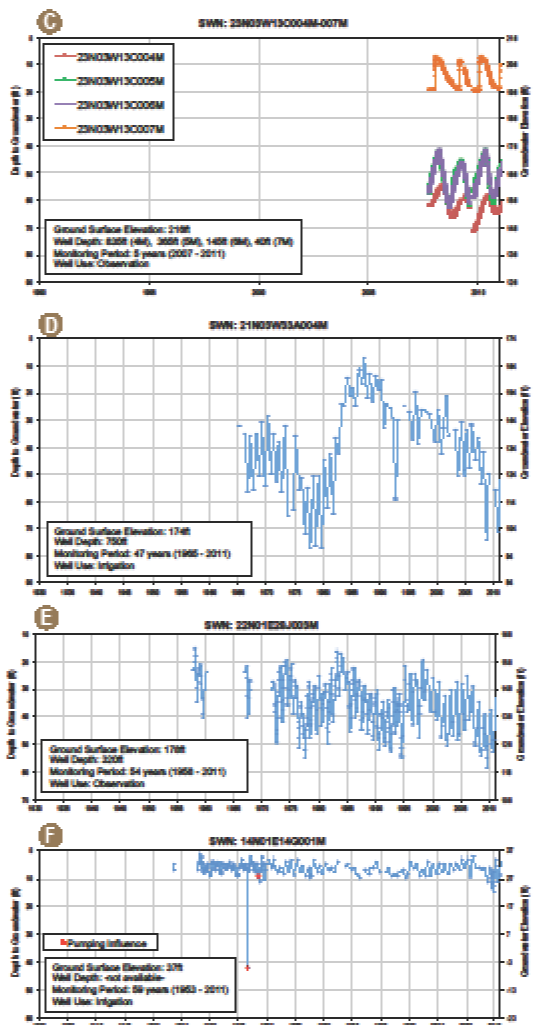




H **Hydrograph 10N01W06D001M**: highlights the impact of drought conditions on groundwater elevations: seasonal measurements showing much greater fluctuations during dry years than during wet years.

I **Hydrograph 06N01W24N001M**: shows the successful recovery of groundwater levels through introduction of surface water supply, which resulted in reducing groundwater demand and facilitating in-lieu groundwater recharge.

J **Hydrograph 07N06E08H001M**: illustrates the typical groundwater level trends observed in the wells located in Zone 40 portion of Sacramento County. The groundwater levels declined prior to the 1980s due to intensive groundwater use for domestic and agricultural purposes. After 1960s, the groundwater levels stabilized as surface water supplies became available for domestic use and as some of the agricultural land was transitioned into new residential developments.



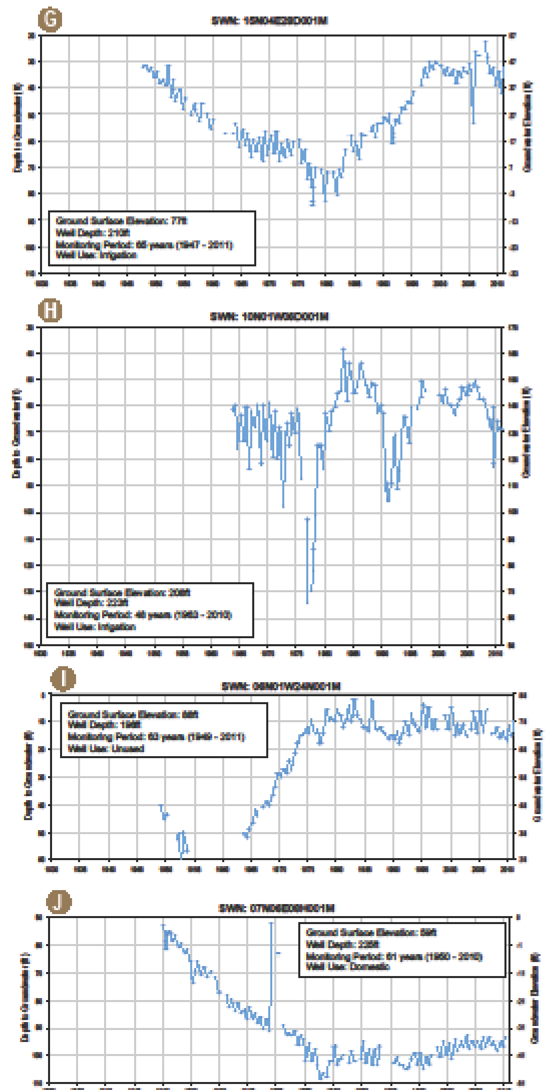
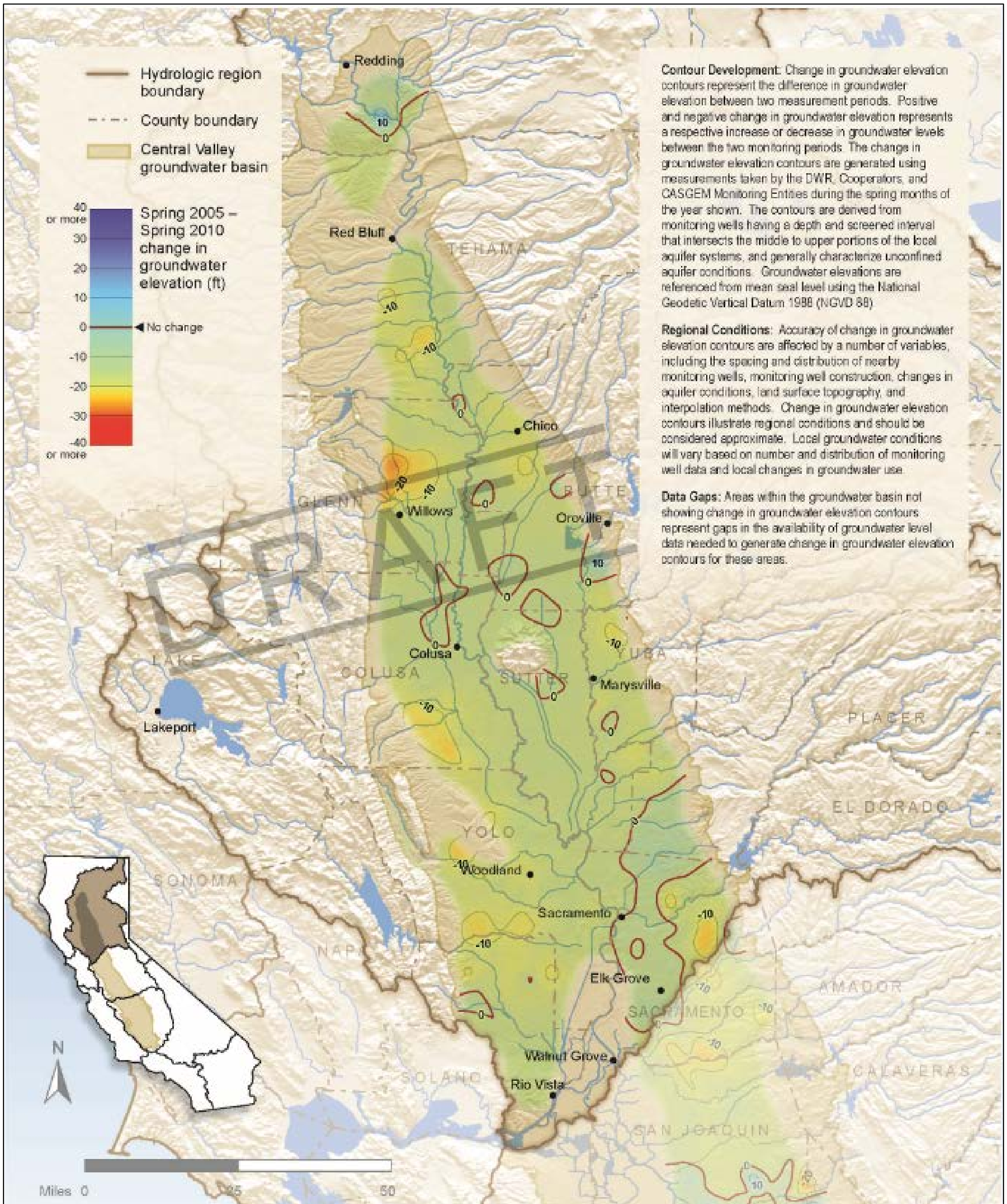


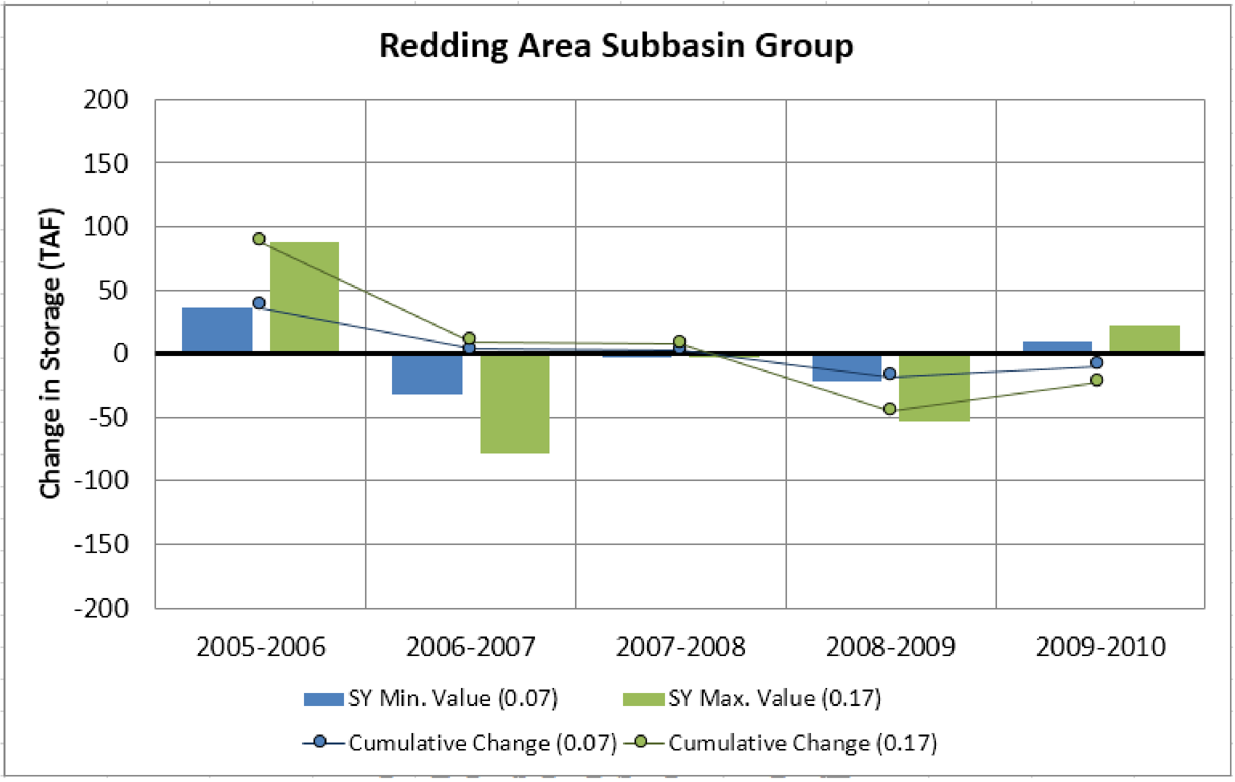
Figure SR-19 Spring 2005 - Spring 2010 Change in Groundwater Elevation Contour Map for the Sacramento River Hydrologic Region



Source: Department of Water Resources, CWP 2013

Figure SR-20 Spring 2010 Annual Change in Groundwater Storage for the Sacramento River Hydrologic Region

A. Redding Area Groundwater Basin



B. Sacramento Valley Groundwater Basin

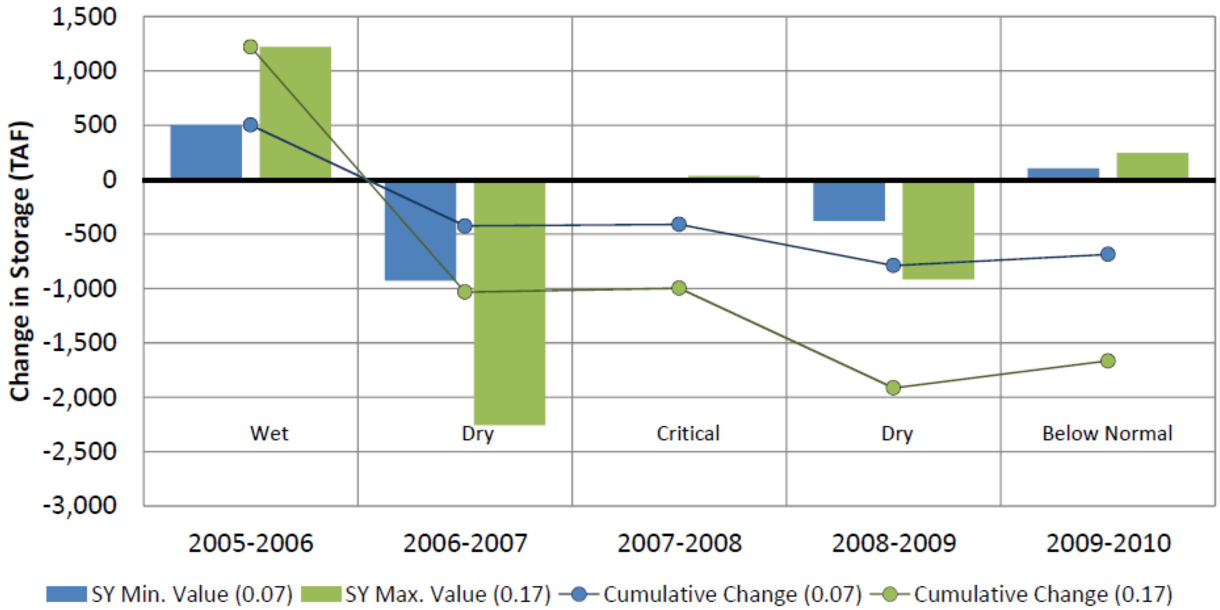
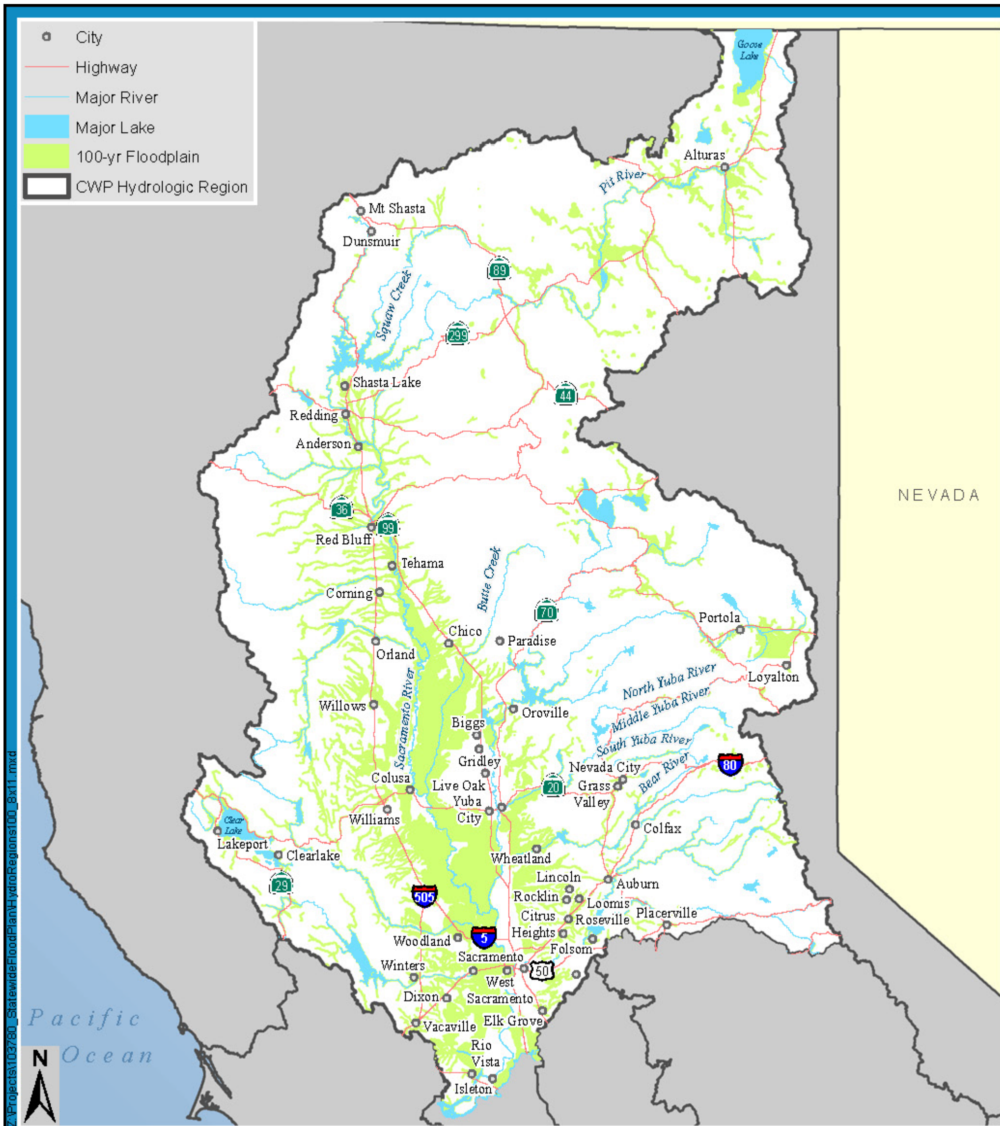


Figure SR-21 Flood Hazard Exposure to the 100-Year Floodplain, Sacramento River Region



Sacramento River Key Results

Total Population:	2,570,300	Transportation Facilities:	1,087
Population Exposed:	200,200	Transportation Segments (miles):	626
Percent of Population Exposed:	8	Essential Facilities:	135
Exposed Structures:	75,000	Lifeline Utilities:	25
Value of Exposed Structure and Contents:	$16.7 Billion	Dept. of Defense Facilities:	5
Total Area (acres)	17.4 Million	Dept. of Defense Facilities (acres):	4,970
Exposed Area (acres)	1,737,300	High Potential Loss Facilities:	108
Percent of Area Exposed:	10	Native American Tribes:	8
Exposed Ag.Crops (acres):	896,900	Native American Tribal Lands (acres):	2,747
Percent of Ag. Crops Exposed:	40	Sensitive Animal Species Exposed:	142
Value of Exposed Ag. Crops:	$1.1 Billion	Sensitive Plant Species Exposed:	203

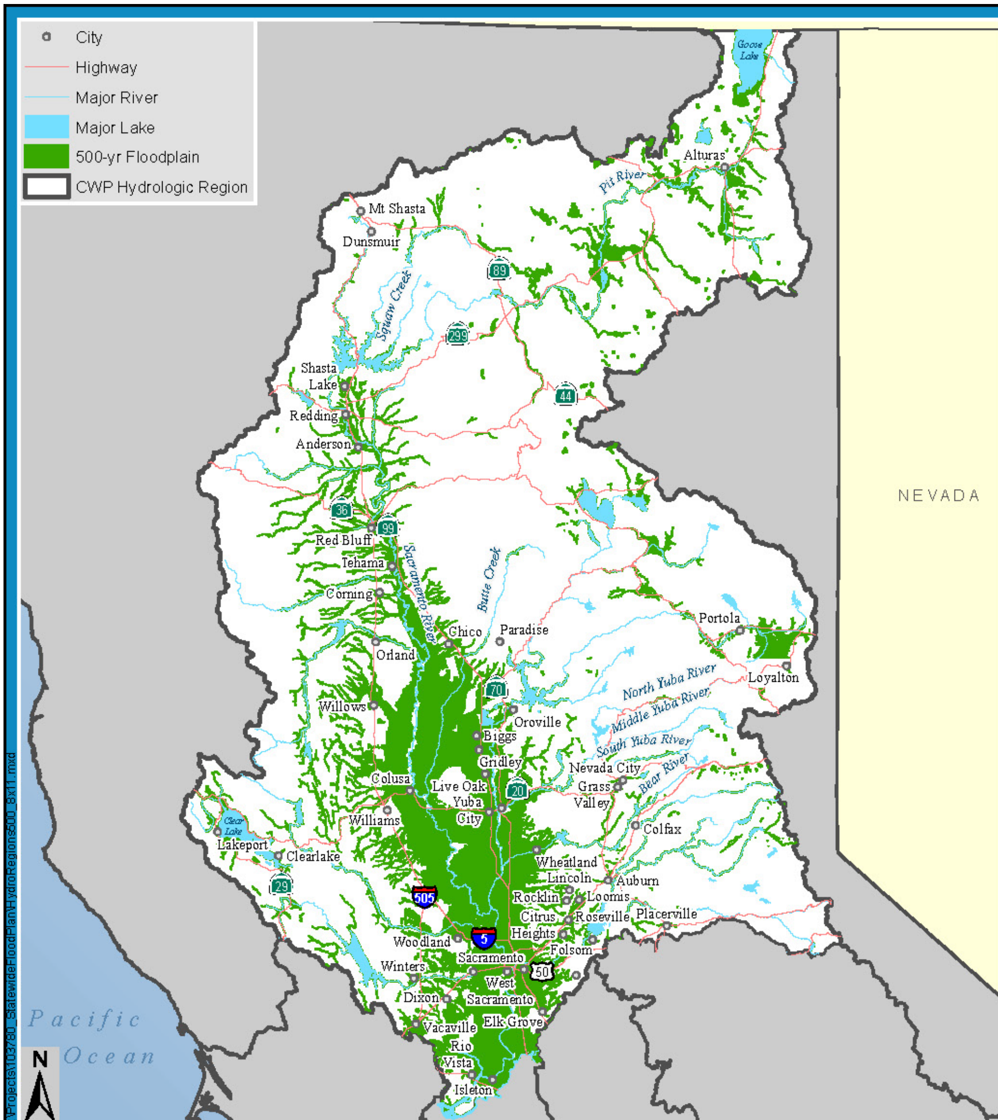
Statewide Flood Hazard Exposure Summary for the Sacramento River Hydrologic Region 100-year Floodplain

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Jan 28, 2013

Figure SR-22 Flood Hazard Exposure to the 500-Year Floodplain, Sacramento River Region



Sacramento River Key Results

Total Population:	2,570,300	Transportation Facilities:	1,620
Population Exposed:	925,800	Transportation Segments (miles):	1,191
Percent of Population Exposed:	36%	Essential Facilities:	510
Exposed Structures:	320,800	Lifeline Utilities:	53
Value of Exposed Structure and Contents:	$66.3 Billion	Dept. of Defense Facilities:	6
Total Area (acres)	17.4 Million	Dept. of Defense Facilities (acres):	5,841
Exposed Area (acres)	2,242,400	High Potential Loss Facilities:	147
Percent of Area Exposed:	13%	Native American Tribes:	8
Exposed Ag.Crops (acres):	1,215,500	Native American Tribal Lands (acres):	2,833
Percent of Ag. Crops Exposed:	54%	Sensitive Animal Species Exposed:	142
Value of Exposed Ag. Crops:	$1.7 Billion	Sensitive Plant Species Exposed:	205

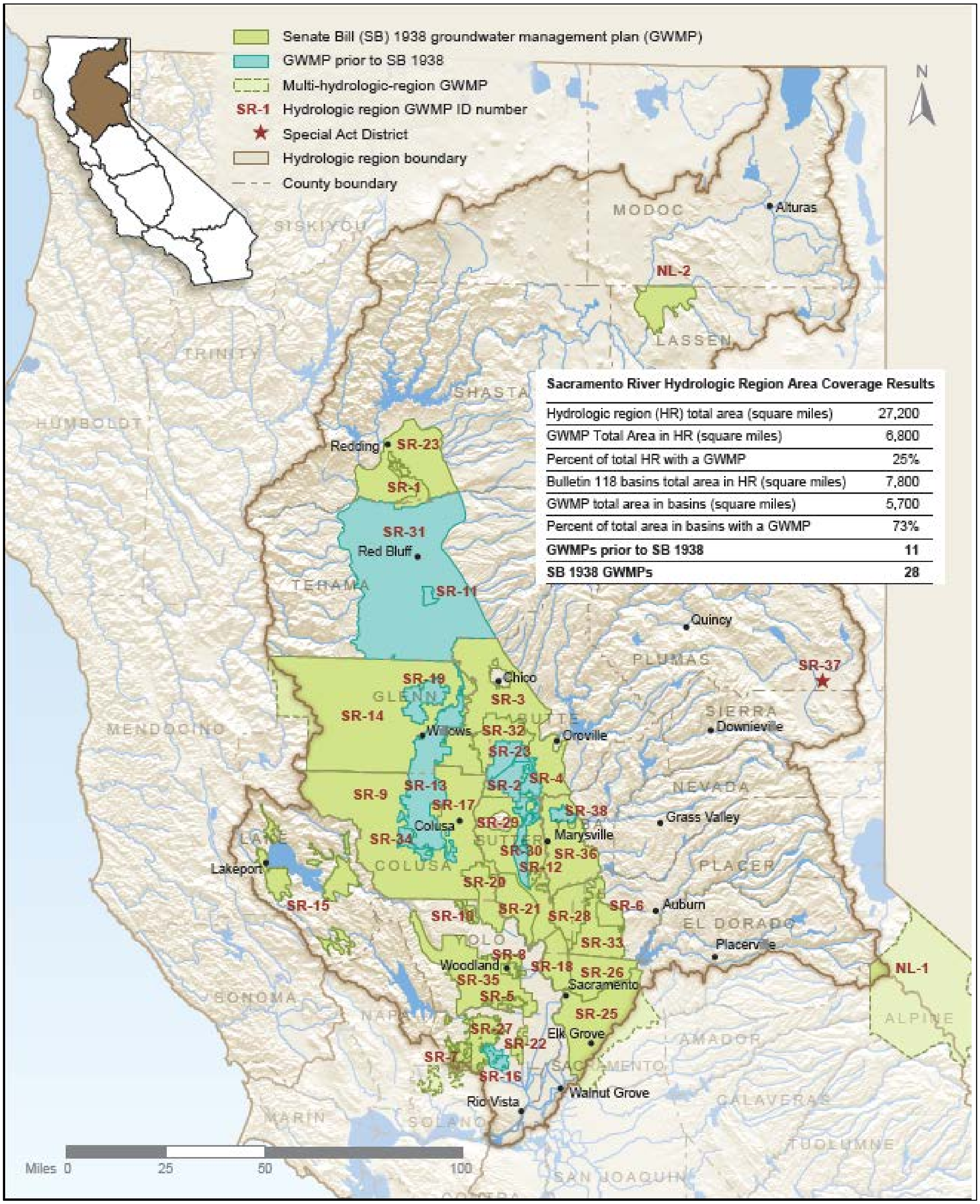
Statewide Flood Hazard Exposure Summary for the Sacramento River Hydrologic Region 500-year Floodplain

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Jan 28, 2013

Figure SR-23 Location of Groundwater Management Plans in the Sacramento River Hydrologic Region



Sacramento River Hydrologic Region Area Coverage Results

Hydrologic region (HR) total area (square miles)	27,200
GWMP Total Area in HR (square miles)	6,800
Percent of total HR with a GWMP	25%
Bulletin 118 basins total area in HR (square miles)	7,800
GWMP total area in basins (square miles)	5,700
Percent of total area in basins with a GWMP	73%
GWMPs prior to SB 1938	**11**
SB 1938 GWMPs	**28**

Figure SR-24 Change in Sacramento River Agricultural and Urban Water Demands for 117 Scenarios from 2006-2050 (thousand acre-feet per year)

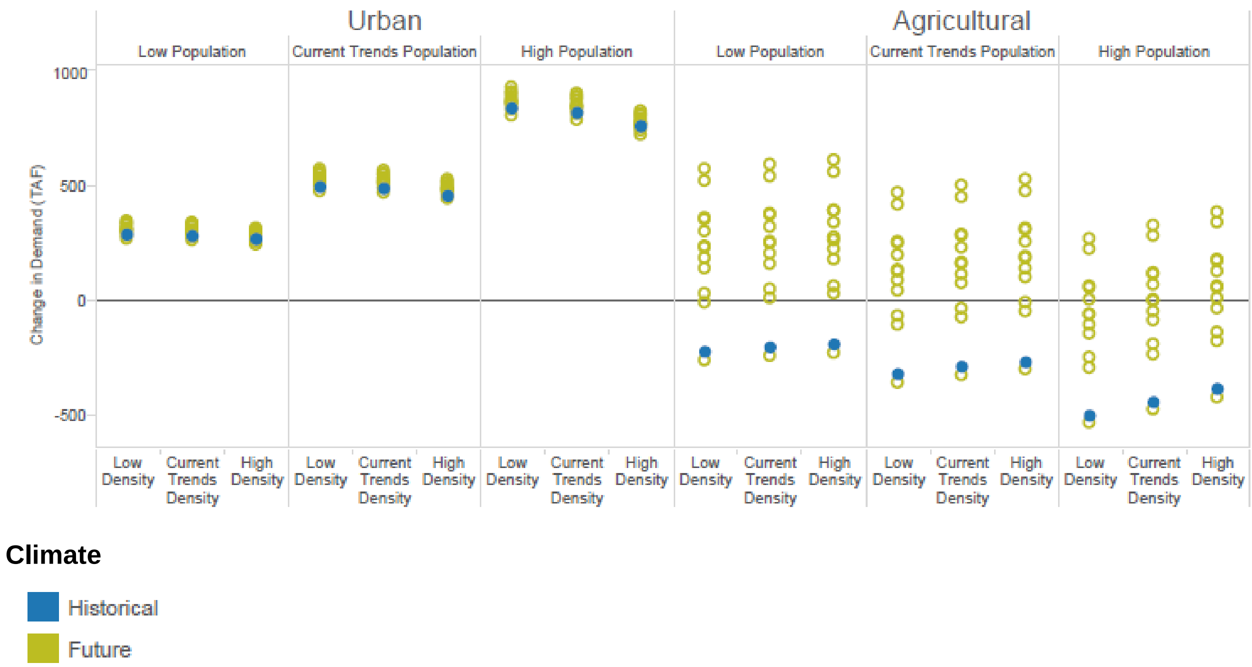


Figure SR-25 Integrated Water Management Planning in the Sacramento River Region

Figure SR-26 Energy Intensity of Raw Water Extraction and Conveyance in the Sacramento Hydrologic Region

Type of Water	Energy Intensity (yellow bulb = 1-500 kWh/AF)	% of regional water supply
Colorado (Project)	*This type of water not available*	0%
Federal (Project)	<250 kWh/AF	28%
State (Project)	<250 kWh/AF	0%
Local (Project)	<250 kWh/AF	30%
Local Imports	*This type of water not available*	0%
Groundwater	<250 kWh/AF	19%

Energy intensity per acre foot of water

Energy intensity (EI) in this figure is the total amount of energy required for the extraction and conveyance of one acre-foot of water and does not include treatment, distribution to point of use, or end use energy (e.g., water heating). These figures should be seen as ranges within which the EI of different sources of each water type would likely fall i.e., a water type with four bulbs should be interpreted to mean that most sources of that water type in the region would have an EI of between 1,501-2,000 kWh/acre-ft of water. Smaller light bulbs represent an EI of greater than zero, and less than250 kWh/acre-ft. EI of desalinated and recycled water is not shown, but is covered in Resource Management Strategies #XX and #YY respectively, Volume 3. (For detailed description of the methodology used to calculate EI in this figure, see Technical Guide, Volume 5 or References Guide, Volume 4 (TBD)).

Box SR-1 California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization Data Considerations

Senate Bill 7x 6 (SBx7 6; Part 2.11 to Division 6 of the California Water Code § 10920 et seq.) requires, as part of the CASGEM program, DWR to prioritize groundwater basins to help identify, evaluate, and determine the need for additional groundwater level monitoring by considering available data listed below:

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, and

8. Any other information determined to be relevant by the DWR.

Using groundwater reliance as the leading indicator of basin priority, DWR evaluated California's 515 alluvial groundwater basins and categorized them into five groups:

- Very High
- High
- Medium
- Low
- Very Low

Box SR-2 Shasta Lake Water Resources Investigation (SLWRI) – Enlarging Shasta Dam and Reservoir

The draft feasibility report and preliminary EIS for enlarging Shasta Dam and Reservoir was released by USBR in November 2011. Copies of the documents can be found at: http://www.usbr.gov/mp/slwri/documents.html. In conducting the investigation, USBR determined that expanding the capacity of Shasta Lake by modifying Shasta Dam would (1) increase survival of anadromous fish in the Sacramento River; (2) improve water supply reliability for agricultural, municipal and industrial (M&I) and environmental water users; and (3) address other related resource needs (USBR 2011b).

Planning Objectives

Planning objectives for the project include (USBR 2011a):

- Increase the survival of anadromous fish populations in the Sacramento River, primarily upstream of RBDD
- Increase water supply and water supply reliability for agricultural, M&I, and environmental purposes to help meet current and future water demands
- Conserve, restore, and enhance ecosystem resources in the Shasta Lake area and along the upper Sacramento River
- Reduce flood damage along the Sacramento River
- Develop additional hydropower generation capabilities at Shasta Dam
- Maintain and increase recreation opportunities at Shasta Lake
- Maintain or improve water quality conditions in the Sacramento River and in the Delta.

Five Alternatives Evaluated

USBR evaluated the feasibility of five alternatives. Increases in dam elevation that were evaluated were 6.5, 12 and 18.5 feet. The alternative identified as providing the greatest net benefit is CP4. CP4 focuses on: "increased anadromous fish survival, while increasing water supply reliability and providing benefits to other resources through an 18.5-foot raise of Shasta Dam and 634,000 acre-foot enlargement of Shasta Reservoir" (USBR 2011a).

Regional Concerns

Sites of cultural significance exist in and around Shasta Lake, many related to historic activities of Native Americans. The Winnemem band of the Wintu Indians have raised concerns about potential impacts of enlarging Shasta Dam on sites they value for historic and cultural significance (USBR 2006).

The McCloud River CRMP, landowners, and various environmental groups have expressed concerns about potential impacts to the McCloud River. The California Wild & Scenic River System Act was amended in 1989 to include portions of the McCloud River (PRC 5093.542). The act states that no new dams, reservoirs, diversions, or water impoundment facilities are to be constructed on the McCloud River from 0.25 miles downstream from the McCloud Dam to the McCloud River Bridge - a reach length of approximately 24 miles. At gross pool, the existing Shasta Lake can inundate just over a mile of river reach upstream from the McCloud Bridge. Raising Shasta Dam would extend this area by about 2/3 of a mile (USBR 2006).

Box SR-3 The Monterey Agreement

DWR and most SWP contractors entered into the Monterey Agreement in 1994. The original long-term contracts for SWP water required the contractors to pay annual charges to fund project bond interest payments, operations and maintenance costs, and other costs regardless of amount of water that was available for delivery. The cost to contractors never changed regardless of whether water was delivered or not. The contracts also required the agricultural contractors to forego deliveries of water before cutbacks to urban contractors would be made during water shortages.

Long-term water contracts were restructured to allow for a more equitable distribution of water during water shortages. One of the outcomes is what is referred to as Table "A" Amounts. Table "A" Amounts is the quantity of project water available to the contractor and, under favorable conditions, the amount of water the contractor will receive. Water is allocated proportionally to all SWP contractors.

The original 1995 EIR for the agreeement was challenged in court for alleged violations of CEQA. This ultimately led to a settlement agreement that was court approved in 2003 and required DWR to prepare a new EIR as well as other actions. One of the actions was a monetary settlement which funded Plumas Watershed Forum restoration efforts within the Feather River watershed. Goals of the Watershed Forum are to:

- Improve retention (storage) of water for augmented base flow of streams
- Improved water quality and stream bank protection
- Improved upland vegetative management
- Improved groundwater retention/storage in major aquifers.

The agreement also based the water supplied to Plumas County on the water supply available from Lake Davis. Water supplied to Plumas County will not be reduced during shortages provided that water is available from Lake Davis. DWR certified the EIR for the Monterey Agreement in 2010.

Box SR-4 Lower Yuba River Accord

The Lower Yuba River Accord (Accord) is the result of negotiations between 17 stakeholders which included local irrigation districts, state and federal resource agencies, and conservation groups. It enables the Yuba County Water Agency (YCWA) to operate the Yuba River Development Project, FERC 2246, for hydropower, irrigation, flood control, recreation and fisheries benefits.

The Accord consists of three agreements: Fisheries Agreement, Conjunctive Use Agreement, and a water purchase agreement between YCWA and DWR. The Fisheries Agreement establishes in-stream flow schedules in the lower Yuba River to improve fisheries protection. The seasonal flow regime was developed from 2001 to 2004 to address stressors to fish as well as flood control requirements, water rights, delivery obligations, and reservoir carryover storage. The Accord and the instream flow schedules underwent CEQA/NEPA review in 2006/2007. The flow schedules were implemented on a pilot program basis in 2006 and 2007. The State of California approved the agreement in 2008 based upon the success of the pilot programs and approved petitions to change the water right permits of YCWA to implement the Accord (LYRMTPG 2010).

The Conjunctive Use Agreement defines the approach for the conjunctive use of surface water and groundwater to ensure availability of local supplies. In separate conjunctive use agreements, member stakeholders will use groundwater to supplement storage releases up to a total of 30,000 af depending on in-stream flow requirements. Members will also use up to 15,000 af of groundwater in support of the Phase 8 Settlement Agreement. The extent to which member stakeholders can provide this amount of groundwater will depend on arrangements made with local landowners.

The water purchase agreement provides for water transfer payments by DWR to YCWA. Revenue from water purchases is intended to fund flood-control and water supply projects in Yuba County. DWR will enter into separate agreements with SWP contractors and the San Luis and Delta-Mendota Water Authority for water allocation and payment. The transferred water will include water released to meet instream flow needs of the lower Yuba River pursuant to the Yuba Accord Fisheries Agreement.

Box SR-5 Central Valley Regional Board Irrigated Lands Regulatory Program

The Irrigated Lands Regulatory Program regulates discharges from irrigated agriculture. Water quality problems that are detected through surface water monitoring are addressed through the development and implementation of focused management plans. This program addresses materials used in agricultural production that may end up in surface water such as pesticides as well as pollutants that may be concentrated or mobilized by agricultural activities such as salt. In this program, coalition groups representing growers monitor to identify constituents of concern. Management plans are developed which identify management practices that individual growers implement to reduce the concentrations of the constituents of concern in surface water. Follow-up monitoring is conducted to confirm that water quality standards are met. Growers work together under a coalition group to meet the program requirements.

Coalition groups active in the Sacramento River Basin are the California Rice Commission, Goose Lake Water Quality Coalition, and Sacramento Valley Water Quality Coalition. Where there are repeated exceedances of water quality objectives, coalitions are required to prepare a management plan that addresses the source and corrective action needed for those exceedances. The Coalitions have developed and implemented management plans addressing chlorpyrifos, diazinon, diuron, malathion, thiobencarb, water column and sediment toxicity, and E. coli (CVRWQCB 2011a). Due to follow up monitoring indicating no water quality exceedances, the coalitions were approved to remove the E. coli management plan for the Pit River Subwatershed, chlorpyrifos management plans for Coon Creek in the Placer-Nevada-South-Sutter-North Sacramento Subwatershed, and toxicity to Ceriodaphnia in Laguna Creek in the Sacramento Amador Subwatershed and in Coon Hollow Creek in the El Dorado Subwatershed (CVRWQCB 2012).

Central Valley Water Board Timber Program

The Timber Program provides review, oversight, and enforcement of timber harvest activities on both private and U.S. Forest Service lands. The primary responsibility of the program is review and inspection of harvest activities. Timber harvest activities pose a threat to water quality with the potential for sediment and herbicide discharges and temperature increases to surface waters. During the past five years within the Sacramento River Hydrologic Region, private timberland owners have submitted 532 timber harvest plans that allowed harvesting on over 173 thousand acres.

Box SR-6 Central Valley Regional Board Water Quality Certification Program

The Water Quality Certification Program evaluates discharges of dredge and fill materials to assure that the activities do not violate state and federal water quality standards. One of the goals of the program is to protect wetlands and riparian areas from dredge and fill activities and to implement state and federal "no net loss" policies for wetlands. Constituents of concern addressed by this program are salts and nutrients, methylmercury and temperature.

Central Valley Regional Board Regulation of Confined Animal Operations

The Central Valley Water Board has a program to regulate discharges from confined animal operations. Water quality issues associated with confined animal operations are salt and nutrients. In 2007, the Central Valley Water Board adopted Waste Discharge Requirements General Order for Existing Milk Cow Dairies (R5-2007-0035) which includes requirements for both the dairy production area and land application area and requires each dairy to fully implement their Waste Management Plan by 2011 and Nutrient Management Plan by 2012. The requirements for the Waste and Nutrient Management Plans are designed to protect both surface and ground water. In the Sacramento River Hydrologic Region, 85 dairies with over 41,000 cows are regulated under this general order. (CVRWQCB 2010a.)

Central Valley Regional Board Regulation of Onsite Wastewater Treatment Systems

The State Water Board has adopted regulations in 2012 for the operation of onsite wastewater treatment systems. Water quality concerns associated with individual disposal systems include salt, nitrates and pathogens. The Board plans to update its guidelines and establish a program based on the new regulations. In the past, the Board has prohibited discharge in problematic service areas. In the Sacramento River Hydrologic Region, the Board has adopted thirteen prohibitions of discharge from individual sewage disposal systems. Currently, twelve of these areas are served by community sewage systems. The other area is the Chico Urban Area in Butte County. The prohibition for the Chico Urban Area covers about 12,000 systems.

Box SR-7 Managing Levee Improvements in Yuba County

by Michael Ward, Department of Water Resources

Yuba County has a long history of flooding. Historical accounts describe several flood events in the 1800's and 1900's. Major flood events in 1955, 1986, and 1997 were due to levee failures. The flood in 1955 was caused by several levee embankment failures which flooded nearly all of Yuba City and the town of Nicolaus, inundating approximately 156 square miles (EIR). This event prompted the formation of the Yuba County Water Agency and the construction of Bullards Bar dam for flood control as well as water storage and hydroelectric power.

Flooding in 1986 was due to a levee embankment failure adjacent to the Yuba River near the town of Linda which flooded nearly 30 square miles including Linda and Olivehurst (EIR). The 1997 flood was due to a levee embankment failure south of Olivehurst flooding nearly 50 square miles, the towns of Olivehurst and Arboga, damaging up to 13,000 homes and destroying up to 800 homes (EIR).

The floods of 1986 and 1997 resulted in a review of the methods used for evaluating levee performance including the effects of levee seepage and the revision of design criteria for strengthening existing levees (USACE 2012). To a large extent, levee deficiencies in the region are related to seepage under and through levee soils during flood events (USACE 2012).

To address these issues, Three Rivers Levee Improvement Authority (TRLIA), a joint powers authority (JPA), was formed by Yuba County and RD 784. The JPA agreement gives TRLIA the authority to provide improved flood protection in the county and the ability to finance improvements and associated operations and maintenance (O&M) (Downey 2009). Using available funding through the Costa-Machado Water Act of 2000 (Prop 13) and Proposition 1E, TRLIA has made improvements to levees of the Yuba, Feather, and Bear Rivers and the Western Pacific Interceptor Channel. Improvements included the installation of slurry walls, relief wells, monitoring wells, stability and seepage berms, new setback levees, rock erosion protection, and widened tow access corridors (Downey 2009). Project objectives include providing flood protection for a flood event with a 1-in-200 chance of exceedance and to incorporate environmental mitigation as appropriate. Levee setbacks provide for habitat restoration and additional riparian habitat.

To help fund the project, Yuba County and local developers established a Mello-Roos Community Facilities District (CFD) to generate the 30 percent local cost share requirement for Proposition funding and to generate additional funding for project costs in excess of available proposition funding. To fund O&M activities, property owners voted for a property assessment based on the benefit to the property. For single-family dwellings, assessments range from $11.12 to $148.04 per year.

Box SR-8 Other Groundwater Management Planning Efforts in the Sacramento River Hydrologic Region

The Integrated Regional Water Management plans, Urban Water Management plans, and Agriculture Water Management plans in the Sacramento River Hydrologic Region that also include components related to groundwater management are briefly discussed below.

Integrated Regional Water Management Plans

The Sacramento River Hydrologic Region includes eight of the 48 IRWM plans that have been accepted or conditionally accepted statewide. Four of the eight IRWM plans have been adopted and are being implemented, while the remaining four are currently in development. Two of the IRWM regions extend into two adjacent hydrologic regions.

Of the four plans that are being implemented, one IRWM planning group says that groundwater in the region is poorly understood due to faulted and fractured geological conditions, and the IRWM plan defers groundwater management to city and county agencies, as well as irrigation districts. A few of the objectives of this group's IRWM plan are to identify suitable groundwater management practices to prevent groundwater contamination, assure that groundwater recharge and extraction are balanced, and to support efforts to understand groundwater movement and quantities in the Sierra Nevada fractured rock systems through more study and analysis.

Another IRWM planning region has very little active groundwater management planning; no area is covered by a groundwater management plan but there is a groundwater management district for one area of the IRWM region. However, the management district is only legislated to monitor groundwater declines from groundwater pumping, and has few groundwater management components to it. The IRWM planning group acknowledges that there is a need for IRWM goals and objectives to be applied to the entire IRWM region.

One of the IRWM planning groups relies on four local agencies, or authorities with active groundwater management plans, for groundwater management. The IRWM plan states that groundwater management is important to the IRWM region for reducing water rights disputes and conflicts due to heavy reliance on groundwater by agricultural and residential users for water supplies. Among the IRWM region's objectives are to identify and resolve issues connected with conjunctive water management practices and groundwater contamination, and to evaluate effectiveness of regional groundwater monitoring systems by identifying data gaps and making recommendations for improvements to the groundwater monitoring systems.

One IRWM plan has been developed to provide guidance on water management planning and to support implementation of projects and programs that would improve water management in the IRWM region. This IRWM group relies on local management of groundwater through the use of the county's SB 1938 compliant groundwater management plan. The IRWM group has identified groundwater management as an important issue to address in order to protect and utilize the groundwater resources in the area in a sustainable manner. The overall goal for groundwater management is to prevent overdraft, protect overlying groundwater rights, and ensure that combined use of surface and groundwater resources sustainably meets current and future water uses.

Urban Water Management Plans

Urban Water Management plans 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 uses. 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 Urban Water Management plan 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 plan updates is currently under evaluation and review by DWR. Because of the time-line, the plans could not be reviewed for assessment for Water Plan Update 2013.

Agricultural Water Management Plans

Agricultural Water Management plans are developed by water and irrigation districts to advance the efficiency of farm water management while benefitting the environment. New and updated Agricultural Water Management plans addressing several new requirements were submitted to DWR by December 31, 2012 for review and approval. These new or updated plans provide another avenue for local groundwater management, but because of the time-line, the plans could not be reviewed for assessment for Water Plan Update 2013.

Box SR-9 Evaluation of Water Mangement Vulnerabilities

The CWP is evaluating how implementing alternative mixes of resource management strategies could reduce the Central Valley vulnerabilities. Management response packages are each comprised of a mix of resource management strategies selected from Volume 3 and implemented at investment levels and locations, as described in the Plan of Study (see Volume 4, Reference Guide, the article "Evaluating Response Packages for the California Water Plan Update 2013, Plan of Study").

Results are presented here for the Sacramento River Region evaluated over 198 combinations of future population growth and climate scenarios. The growth scenarios are defined in Table SR-23. Future climate conditions were evaluated over 22 alternative climate scenarios including five derived from historical temperature are precipitation estimates, five from historical conditions with an added temperature trend, and twelve downscaled global climate model estimates described in Chapter 5, Volume 1. For each scenario, an assessment of water supply, demand, and unmet demand in the urban and agricultural sectors was performed. The model also reported on changes in groundwater and how frequently instream flow requirements were met.

Reliability, defined as the percentage of years in which demand is sufficiently met by supply, is one of several ways the CWP summarizes the projections of future urban and agricultural conditions. Figure SR-A show the range of reliability results for the urban and agricultural sectors in the Sacramento River region. In the figure, each dot indicates the reliability for one of the 198 simulations, but many of the dots overlap. The vertical lines indicate the half way point of each distribution, and the shaded areas indicate the results that fall within the middle half of the distribution (between the 25th and 75th percentiles). The figure clearly shows that both the urban and agricultural sectors in the Sacramento River region are projected to remain highly reliable across the futures evaluated.

PLACEHOLDER Figure SR-A Range of urban and agricultural reliability results across scenarios for the Sacramento River region

Groundwater resources and environmental flows were evaluated for performance under the plausible futures. Figure SR-B shows the change in groundwater from the present to 2050 across the 198 scenarios. About 40% of the futures lead to groundwater declines in the Sacramento River region. In general, the simulations based on the historical climate conditions range between no increase to 8% increases in groundwater storage, whereas the futures based on the GCM-derived climate scenarios span the range of declines of 9% to increases of about 5%.

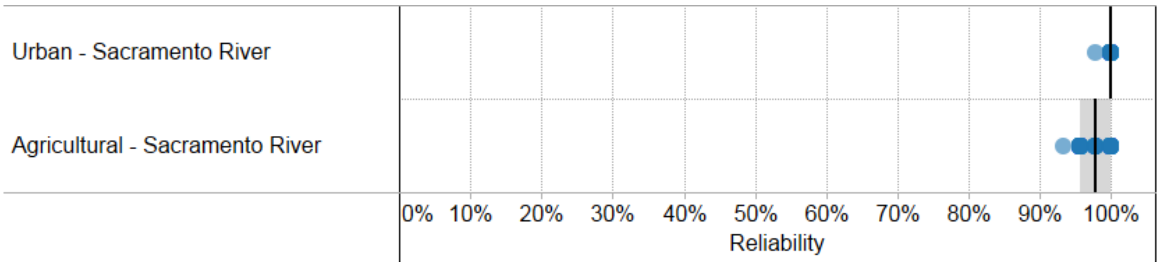
PLACEHOLDER Figure SR-B Range of changes in groundwater storage for the Sacramento River Region across scenarios

Figure SR-C shows the reliability across the 45-year simulation period for the required instream flows for the Sacramento River region across the 198 scenarios. Most Sacramento River instream flow requirements are met with high reliability across the futures. Notable exceptions are the American River and Sacramento River instream flow requirements. In these cases, reliability is less than 100% for more than 75% of the futures.

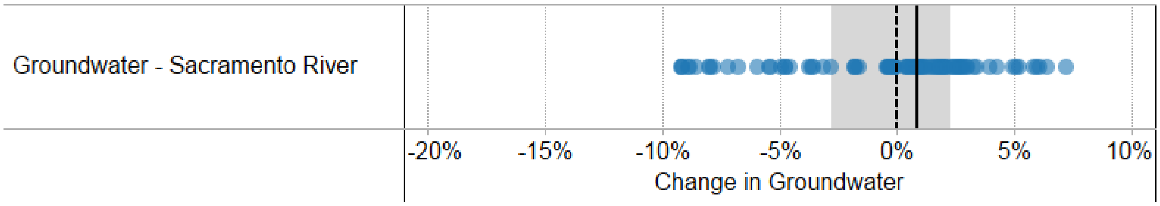
PLACEHOLDER Figure SR-C Range of instream flow reliability for the Sacramento River region across futures

In summary, the Sacramento River region is projected to remain highly reliable in both the urban and agricultural sectors. There is a modest range of projected changes in groundwater levels between 2012 and 2050, centered around no change. Instream flows remain reliable for all but the American River and Sacramento River flow requirements.

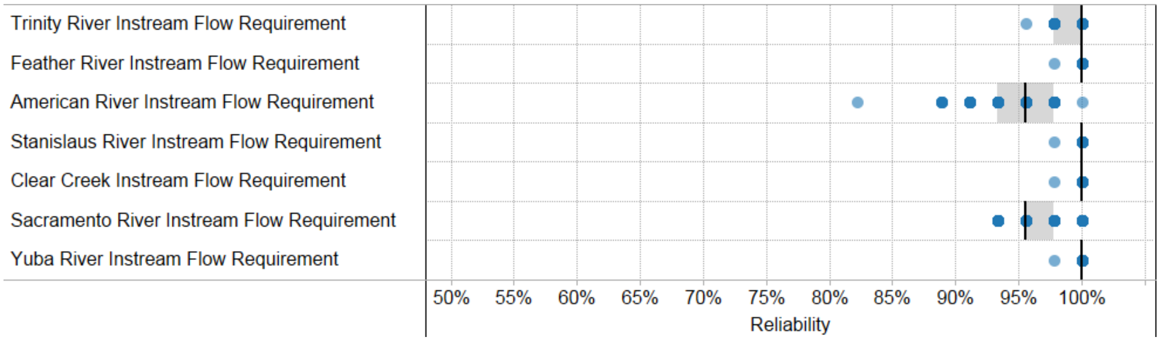
Box SR-9 Figure SR-A Range of Urban and Agricultural Reliability Results across Scenarios for the Sacramento River Region



Box SR-9 Figure SR-B Range of Change in Groundwater Storage for the Sacramento River Region across Scenarios



Box SR-9 Figure SR-C Range of Instream Flow Reliability for the Sacramento River Region across Scenarios



Box SR-10 Statewide Conjuctive Management Effort in California

The effort to inventory and assess conjunctive management projects in California was conducted through literature research, personal communication, and documented summary of the conjunctive management projects. The information obtained was validated through a joint DWR-ACWA survey. The survey requested the following conjunctive use program information:

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

To build on the DWR/ACWA survey, DWR staff contacted by telephone and email the entities identified to gather the following additional information:

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

Statewide, a total of 89 conjunctive management and groundwater recharge programs were identified. Conjunctive management and groundwater recharge programs that are in the planning and feasibility stage are not included in the inventory.