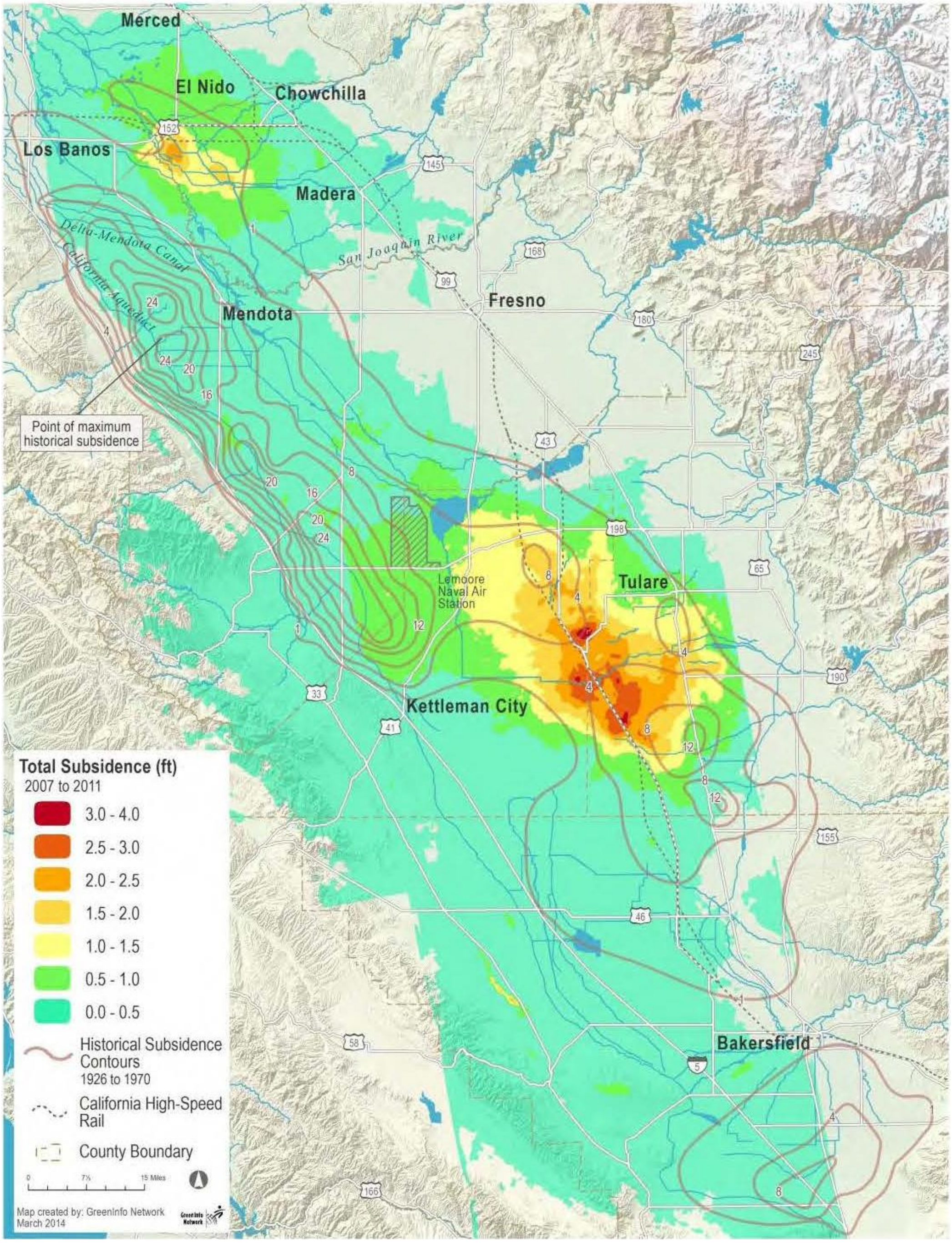


Source: California Water Foundation 2014

Figure 6-15. Land Subsidence in San Joaquin Valley between January 2007 to March 2011 (compiled from InSAR analysis data)

A 2013 USGS study found that the northern portion of the Delta-Mendota Canal was stable or experienced little subsidence from 2003 to 2010. The southern portion of the Delta-Mendota Canal subsided as part of a large area of subsidence centered near the town of El Nido. Subsidence measurements indicated more than 20 millimeters of subsidence from 2008 to 2010 (Sneed et al 2013). Land subsidence appears to be continuing in various areas of the San Joaquin Groundwater Basin.

Groundwater Quality Groundwater quality varies throughout the San Joaquin Valley Groundwater Basin. The GAMA Program's Priority Basin Project evaluates statewide groundwater quality and sampled 67 wells in the northern San Joaquin Valley region; 79 wells in the central region (includes Modesto, Turlock, Merced, and Uplands subbasins) and 126 wells in the southern region (Kings, Kaweah, Tule, and Tulare basins) between 2004 and 2006. Water quality data was analyzed for inorganic constituents (e.g., nutrients, radioactive constituents, TDS, and iron/manganese); special interest constituents (e.g., perchlorate) and organic constituents (e.g., solvents, gasoline additives, and pesticides).

Inorganic Constituents Arsenic, vanadium and boron were the trace elements that were most frequently detected at concentrations greater than the MCL within the basin. Aluminum, barium, lead, antimony, mercury, valadium, and fluoride were also detected at concentrations above the MCL in less than two percent of the sampled wells (Belitz 2010, Bennett 2010, Burton 2012).

Nutrients such as nitrate and nitrite are naturally present at low concentrations in groundwater. High and moderate concentrations generally occur as a result of human activities, such as applying fertilizer to crops. Livestock, when in concentrated numbers, and septic systems also produce nitrogenous waste that can leach into groundwater. Nitrate was present at concentrations greater than the MCL in two percent of the sampled wells in the northern and central portion of the basin and six percent of the wells in the southern region of the basin (Belitz 2010, Bennett 2010, Burton 2012).

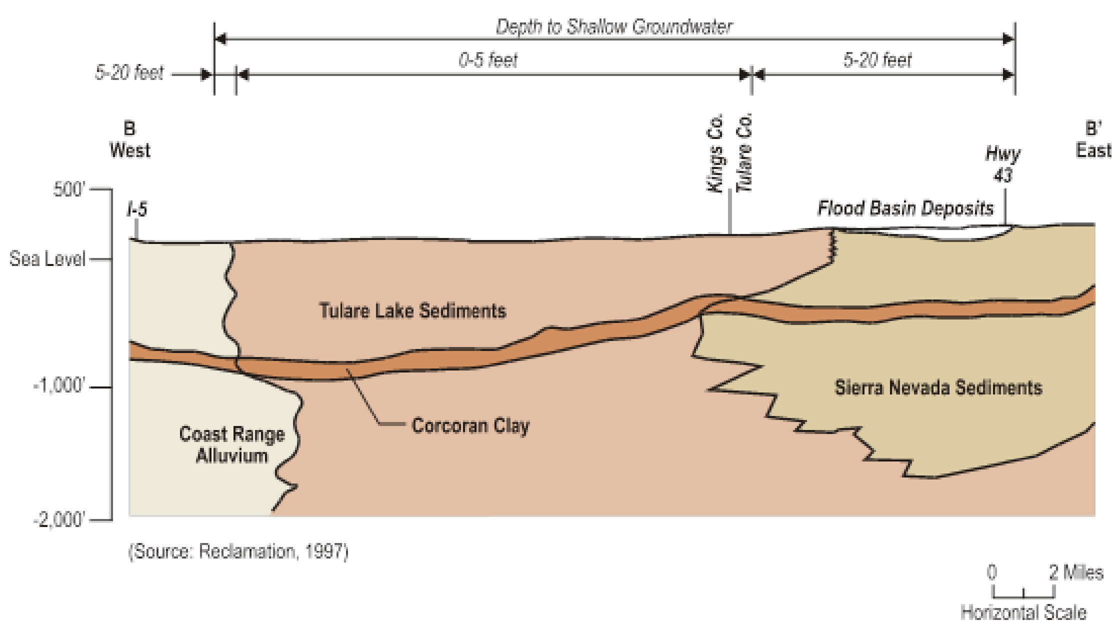
The DDW and USEPA's secondary drinking water standard for TDS is 500 mg/L, and the agricultural water quality goal for TDS is 450 mg/L. TDS concentrations were greater than the upper limit in about two percent of the wells in the central portion of the valley and in about six percent of the primary aquifers in the northern portions of the basin (Belitz 2010, Bennett 2010, Burton 2012). TDS concentrations in the northern portion of the San Joaquin Valley Groundwater Basin are generally higher than in the Sacramento Valley Groundwater Basin. Concentrations of TDS along the east side of the Basin are generally lower than along the west side, as a result of higher quality water recharging the aquifer and soil types.

Organic Constituents Solvents were detected at concentrations greater than the MCL in less than one percent of the sampled wells within the basin. Other VOCs (e.g., trihalomethanes and organic synthesis reagents) were not detected at concentrations above MCLs in the sampled wells (Belitz 2010, Bennett 2010, Burton 2012).

6.1.3.3 Tulare Lake Hydrologic Region

San Joaquin Valley Groundwater Basin, Southern Portion The Southern Portion of the San Joaquin Valley Groundwater Basin extends from the Fresno-Madera County line through Kings and Tulare counties into Kern County. The South San Joaquin Groundwater Basin covers approximately 8,000 square miles.

Geology, Hydrogeology, and Hydrology Similar to the Northern Portion of the San Joaquin Valley Groundwater basin, a significant hydrogeologic feature in the southern basin is the Corcoran Clay. This clay layer divides the aquifer system into two distinct aquifers, an unconfined to semi-confined upper aquifer and a confined aquifer below as shown in Figure 6-16. Both aquifer systems are composed of formations derived from the deposition of Sierra Nevada sediment in the eastern portions of the basin, and from deposition of Coast Range sediments in western portions of the basin. Overlying these formations are flood plain deposits. The axis of the basin contains Tulare Lake sediments. These Tulare Lake sediments are estimated to be more than 3,600 feet thick, with a lateral extent of more than 1,000 square miles (Page 1986). Figure 6-16 shows the cross section for the Southern Portion of the San Joaquin Groundwater Basin and the location of this cross section is show in Figure 6-13.



Source: Reclamation 1997

Figure 6-16. Geologic Cross Section of the Southern Portion of the San Joaquin Valley Groundwater Basin

Groundwater in the unconfined upper aquifer system is recharged by streambed infiltration, rainfall infiltration, and lateral inflow along the basin boundaries. Average annual precipitation in the San Joaquin Valley ranges from 5 to 18 inches (Faunt 2009). The lower confined aquifer is recharged primarily from lateral inflow from the eastern portions of the basin, beyond the eastern extent of the Corcoran Clay. Precipitation in the Sierra Nevada to the east of the basin can be as high as 65 to 75 inches, although much of it is in the form of snow. Peak runoff in the basin generally lags precipitation by five to six months (Bertoldi 1991).

The main surface water features in the southern portion of the San Joaquin Valley Groundwater Basin are the Kern, Kaweah, and Kings Rivers. Agricultural development in the area, with the resultant decline in groundwater levels, has caused the majority of the rivers and streams to lose water to the aquifer system.

Groundwater Production, Levels, and Storage See Groundwater Production, Levels, and Storage discussion under Chapter 6.1.3.2 for details.

Groundwater-Related Land Subsidence See Groundwater-related land subsidence discussion under Chapter 6.1.3.2 for details.

Groundwater Quality See Groundwater Quality discussion under Chapter 6.1.3.2 for details.

Panoche Valley Groundwater Basin Panoche Valley is an elongated northwest-southeast trending basin in the Coast Range Mountains of eastern San Benito County. Panoche Valley Groundwater Basin is part of the Tulare Lake Hydrologic Region. San Benito County Water District (SBCWD) is the only CVP water service contractor overlying the Panoche Valley Groundwater Basin.

Geology, Hydrogeology, and Hydrology The basin is bounded in the northwest by the Franciscan Formation, to the northeast and southeast by Upper Cretaceous marine sedimentary rocks and to the southwest by Lower Miocene marine rocks (DWR 2003). The water bearing unit is most likely formed of alluvium, Quaternary nonmarine terrace deposits and Plio-Pleistocene nonmarine sediments (DWR 2003).

Panoche Creek, Griswold Creek, and their tributaries drain the valley eastward to the San Joaquin Valley. Average precipitation values range from nine inches for the majority of the valley to 13 inches at the western margin.

Groundwater Production, Levels and Storage Bulletin 118 (DWR 2003) reports groundwater depth varying from 30 to over 300 feet based on data collected from 1967 to 2000. Groundwater levels trends have been showing a steady increase since the 1970s, levels have risen as much as 130 feet and on an average up to 40 feet throughout the basin (DWR 2003). No specific information on groundwater production and storage within this basin was found.

Groundwater-Related Land Subsidence No specific published information on groundwater related land subsidence within the basin was found.

Groundwater Quality Salinity is a concern in groundwater in the Panoche Valley Groundwater Basin. Salinity is of the sodium sulfate type and the average TDS is 1,300 mg/L with a range of 394 to 3,530 mg/L. Electrical Conductivity (EC) varies between 630 to 4,090 micromhos per centimeter (µmhos/cm) and averages 1,540 µmhos/cm (DWR 2003).

6.1.3.4 San Francisco Bay/Central Coast Hydrologic Regions

In addition to the groundwater basins discussed in this section there are several smaller basins underlying the East Bay Municipal Utility District and SBCWD. However since these contractors do not heavily rely on groundwater from these smaller basin, they are not discussed in this section. Figure 6-17 shows the groundwater basins and subbasins within the Central Coast and San Francisco Bay Hydrologic Regions.

Santa Clara Valley Groundwater Basin The Santa Clara Valley Groundwater Basin extends over Santa Clara, San Mateo, and Alameda counties and includes the Santa Clara, San Mateo Plain, Niles Cone and East Plain subbasins. The East Bay Plain subbasin is a northwest trending alluvial plain bounded on the north by San Pablo Bay and on the east by the contact with Franciscan Basement rock. To its south lies the Niles Cone groundwater basin bounded on the east by the Diablo Range and on the west by the San Francisco Bay. The Santa Clara subbasin lies to the south of the Niles Cone subbasin occupying a structural trough parallel to the northwest trending Coast Range. The Diablo Range bounds it on the west and the Santa Cruz Mountains form the basin boundary on the east. The San Mateo groundwater subbasin lies to the northwest of the Santa Clara subbasin. The San Mateo subbasin occupies a structural trough, sub-parallel to the northwest trending Coast Range, at the southwest end of San Francisco Bay. San Francisco Bay constitutes its eastern boundary. The Santa Cruz Mountains form the western margin of the San Mateo basin.

Geology, Hydrogeology, and Hydrology The Santa Clara Valley Groundwater Basin includes continental deposits of unconsolidated to semi-consolidated gravel, sand, silt and clay. Two members form this group, the Santa Clara Formation of Plio-Pleistocene age and the younger alluvium of Pleistocene to Holocene age (DWR 1975). The combined thickness of these two units probably exceeds 1,500 feet (DWR 1967).

The Santa Clara Formation is of Plio-Pleistocene age and rests unconformably on impermeable rocks that mark the bottom of the groundwater subbasin (DWR 1975). The Santa Clara Formation is exposed only on the west and east sides of the Santa Clara Valley. The exposed portions are composed of poorly sorted deposits ranging in grain size from boulders to silt (DWR 1975). Well logs indicate that permeability increases from west to east and that in the central part of the valley permeability and grain size decrease with depth (DWR 1975).

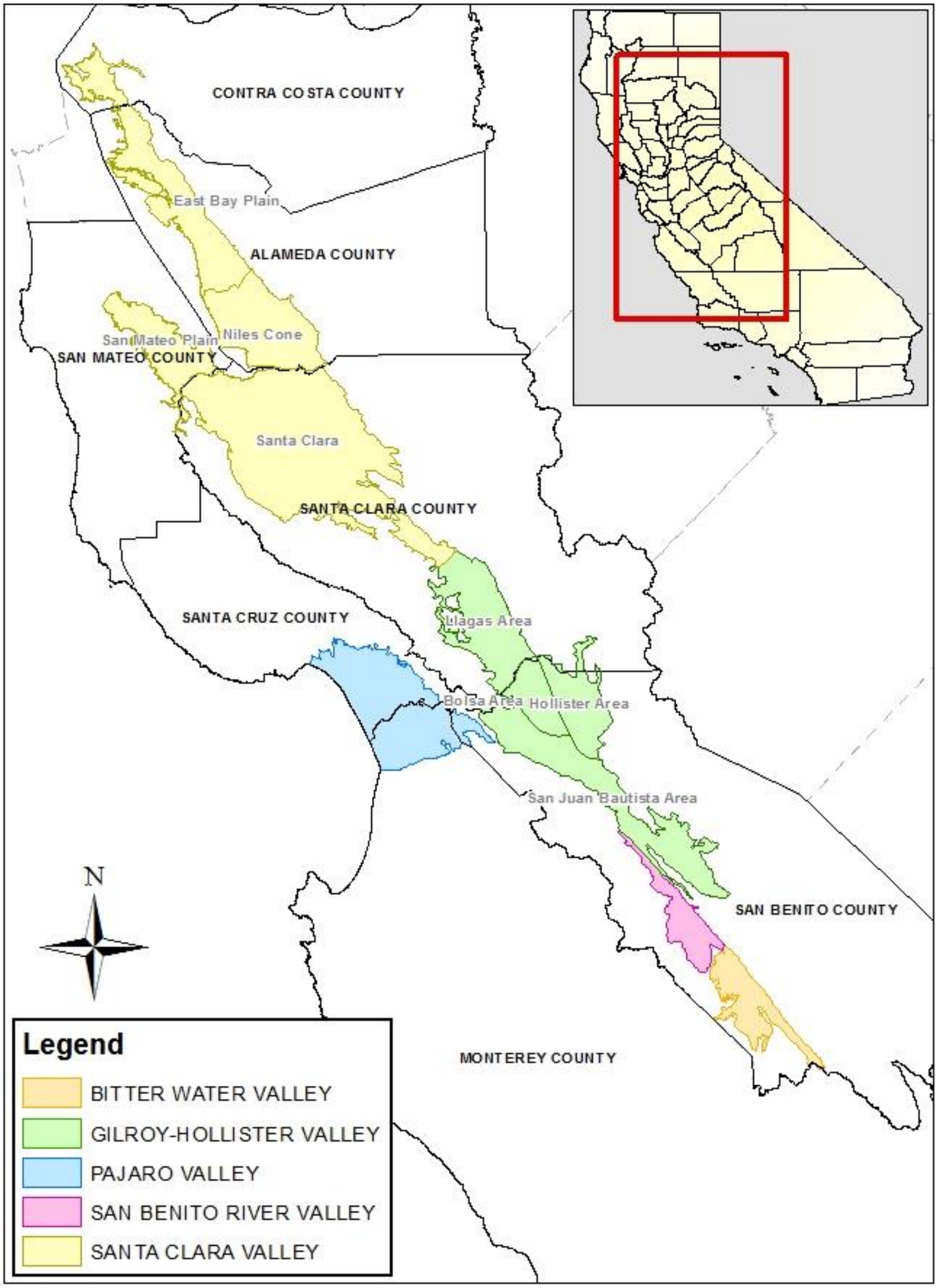


Figure 6-17. Central Coast and San Francisco Hydrologic Region Groundwater Basins

In the Santa Clara Valley, water is primarily present in the Pleistocene to Holocene alluvium deposits. The permeability of the valley alluvium is generally high and principally all large production wells derive their water from it (DWR 1975). Valley alluvium is deposited as a series of convergent alluvial fans comprised generally of unconsolidated gravel, sand, silt, and clay. It becomes progressively finer-grained at the central portions of the valley. A confined zone is created in the northern portion of the subbasin overlain by a clay layer of low permeability (SCVWD 2001). The southern portion of the subbasin is generally unconfined and contains no thick clay layers (SCVWD 2001).

Natural recharge occurs principally as infiltration from streambeds that exit the upland areas within the drainage basin and from direct percolation of precipitation that falls on the basin floor. Annual precipitation for the Santa Clara basin ranges from less than 16 inches in the valley to more than 28 inches in the upland areas (DWR 2003).

The main surface water features in the Santa Clara groundwater subbasin are the tributaries to San Francisco Bay including Coyote Creek, Guadalupe River, and Los Gatos Creek. SCVWD conducts an artificial recharge program. District-wide controlled in-stream recharge accounts for about 45 percent groundwater recharge in district facilities (SCVWD 2001). In-stream recharge occurs along stream channels in the alluvial apron upstream from the confined zone. Spreader dams (creating temporary or permanent impoundments in the stream channel) are a key component of the in-stream recharge program, increasing recharge capacity by approximately 10 percent (SCVWD 2001).

Groundwater Production, Levels, and Storage SCVWD manages the Santa Clara Valley subbasin. Groundwater is pumped within the district by major water retailers, well owners, and agricultural users. Annual average groundwater pumping within the Santa Clara Valley subbasin has remained fairly constant over the years. Figure 6-18 shows historic groundwater pumping from 2000 to 2009 within the basin.

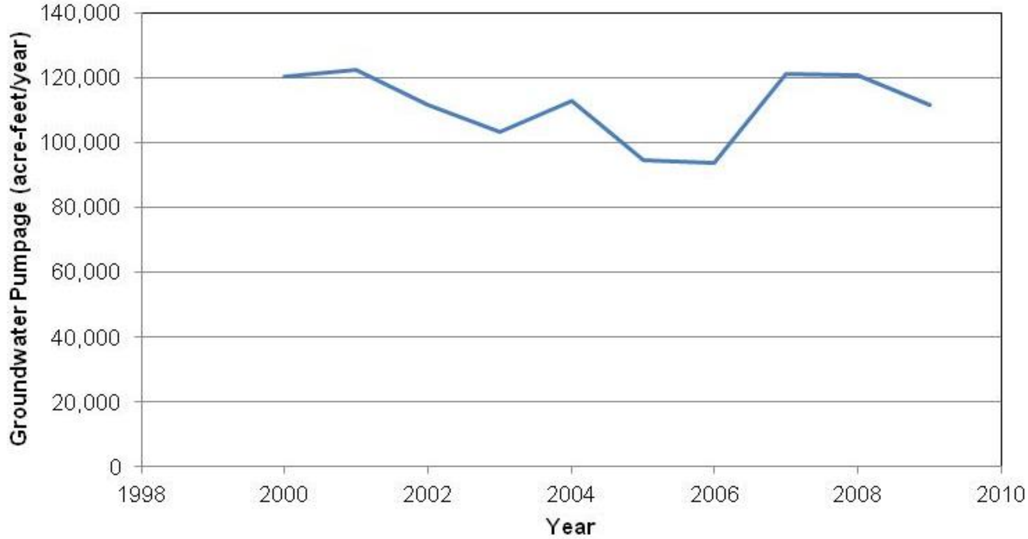


Figure 6-18. Historic Groundwater Pumping Within Santa Clara Valley Subbasin

Historically, since the early 1900s through the mid-1960s groundwater level declines from groundwater pumping have induced subsidence in the Santa Clara Valley subbasin and caused degradation of the aquifer adjacent to the bay from saltwater intrusion. Prior to surface water import via the Hetch Hetchy and South Bay Aqueducts and the introduction of an artificial recharge program, water levels declined more than 200 feet in the Santa Clara Valley (SCVWD 2000). SCVWD has also implemented various recharge programs that use local runoff and imported water deliveries to recharge groundwater through approximately 390 acres of recharge ponds and 90 miles of local creeks to stop groundwater overdraft and land subsidence (SCVWD 2001). Groundwater levels have generally increased since 1965 as a result of increased in-stream and off-stream recharge programs and decreased pumping due to increase in availability of imported surface water (SCVWD 2001). Figure 6-19 shows the location of the monitoring wells within Santa Clara Valley and the groundwater elevation at the wells.

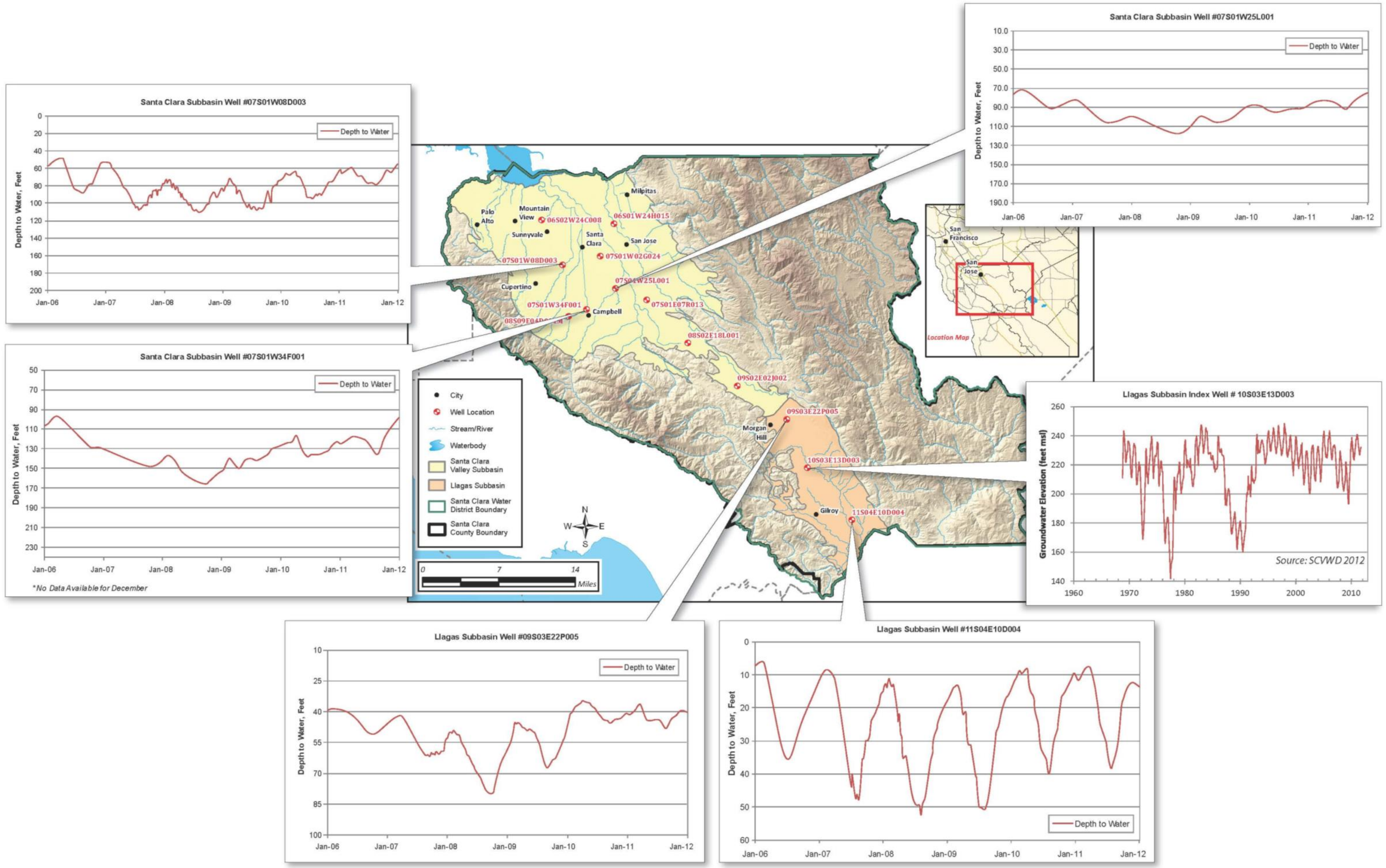


Figure 6-19. Historic Groundwater Elevations at Selected Wells in the Santa Clara Valley and Llagas Subbasin.

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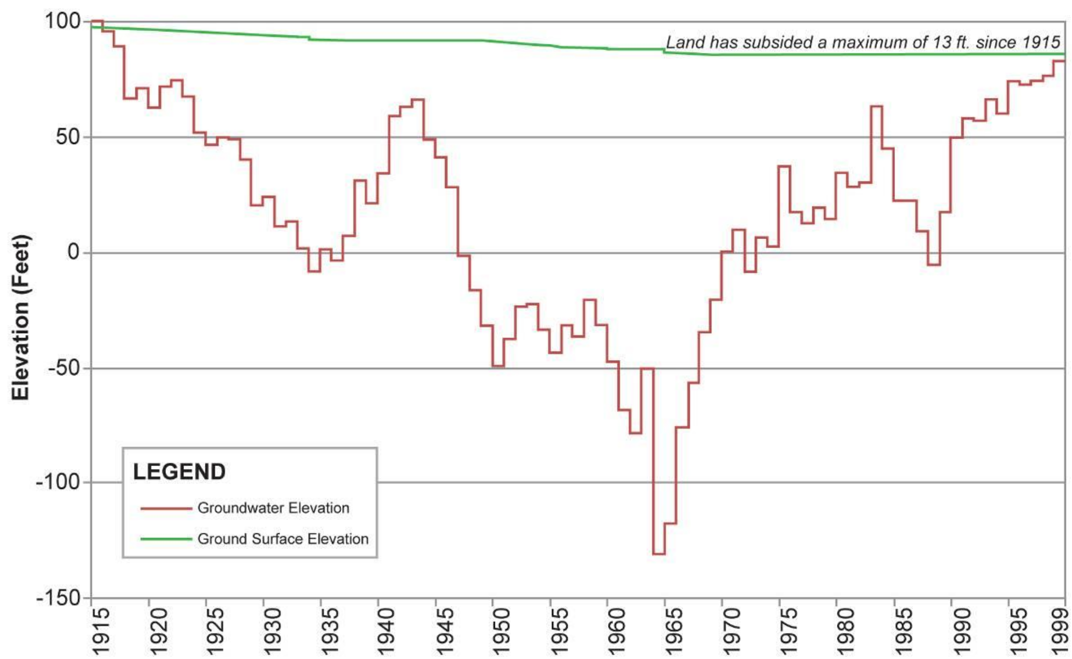
The operational storage capacity of the Santa Clara Valley subbasin is estimated to be 350,000 AF (SCVWD 2001). The operation storage capacity is less than the total storage capacity of the basin and accounts for available pumping capacity, avoidance of land subsidence, and problems associated with high groundwater levels. This estimate of operation storage capacity is based on an area defined by SCVWD that is approximately 15 square miles smaller than the Santa Clara Valley subbasin boundaries as defined in DWR's Bulletin 118 (DWR 2003).

Groundwater-Related Land Subsidence Historically, Santa Clara County has experienced as much as 13 feet of subsidence caused by excessive pumping of groundwater. One serious consequence of subsidence in Santa Clara County was that lands near the Bay sank below sea level between 1940 and 1970, enabling salt water to intrude upstream through the mouths of rivers dramatically affecting the riparian habitat of the rivers. Land subsidence also increased potential for tidal flooding (SCVWD 2000). Figure 6-20 shows the elevation of groundwater at the downtown San Jose index well (7S01E07R013) and the land subsidence measured at First and St. James Streets, San Jose.



Source: SCVWD 2000

Figure 6-20. Land Subsidence at San Jose Index Well

Groundwater Quality Though groundwater quality in the Santa Clara Valley is hard, it is suitable for most uses and drinking water standards are met at public supply wells without the use of treatment methods (SCVWD 2001). Groundwater alkalinity in the Santa Clara Valley is generally bicarbonate type with sodium and calcium being the principal cations (DWR 1975).

Groundwater in the region has elevated mineral levels which could be associated with historical saltwater intrusion observed in the northern basin due to land subsidence (SCVWD 2001). Some wells with elevated nitrate concentration have been identified in the southern portion of the basin (SCVWD 2001).

San Benito River Valley Groundwater Basin The San Benito River Valley Groundwater Basin occupies the middle reaches of the San Benito River Valley within the San Andres Fault Rift Zone and a dissected upland area of Middle-Miocene, nonmarine rocks west of the San Andres Fault. The basin is bounded on the west and southwest by granitic and volcanic rocks along the Pinnacles and Chalone Creek Faults. SBCWD is the only CVP water service contractor overlying the San Benito River Valley Groundwater Basin. No published information on groundwater resources within the basin was found.

Pajaro Valley Groundwater Basin The Pajaro Valley Groundwater Basin is bounded to the west by Monterey Bay and to the east by the San Andreas Fault, adjacent pre-Quaternary formations, and the Santa Cruz Mountains beyond. Pajaro Valley Water Management Agency (PVWMA) is the only CVP water service contractor overlying this groundwater basin. PVWMA is dependent on groundwater for their water supply. Although the agency has a CVP water service contract for 19,900 AFY, the pipeline connecting PVWMA and the CVP was never built due to the high cost of construction, local opposition to construction of pipeline, and concerns over CVP supply reliability (Levy et al. n.d.).

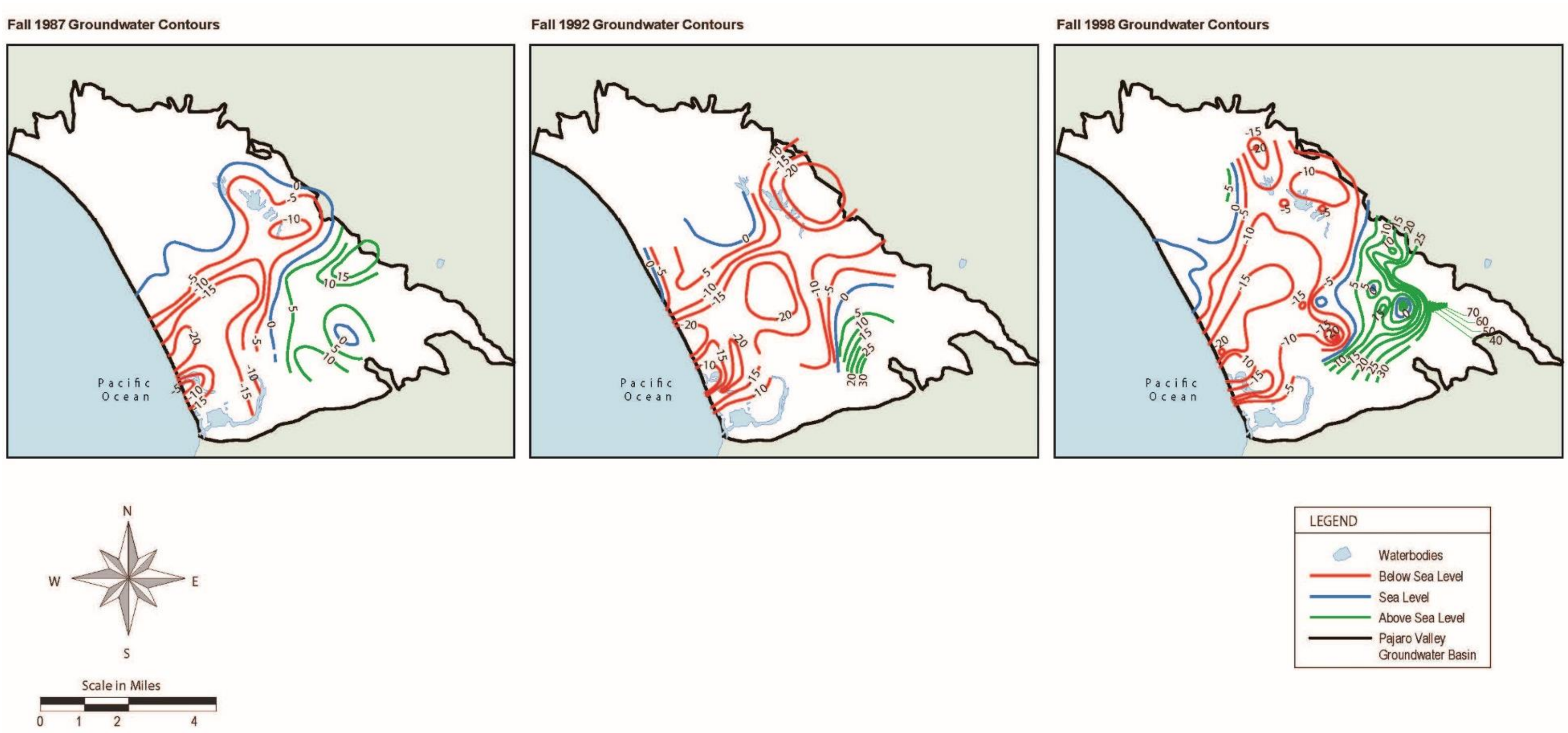
Geology, Hydrogeology, and Hydrology The water-bearing formations of the basin include the Purisima Formation, the Aromas Red Sands, Terrace and Pleistocene Eolian Deposits, Quaternary alluvium and Dune Deposits (DWR 2003). The alluvium deposits vary in thickness between 50-300 feet and are composed of Pleistocene terrace deposits, which is overlain by Holocene alluvium and then by Holocene dune sands; the dune sands are largely unsaturated (DWR 2003). Terrace deposits consist of unconsolidated basal gravel, sand, silt, and clay; alluvium consists of sand, gravel and clay deposited in the Pajaro River flood plain (DWR 2003). The basal gravel has good hydraulic continuity with the underlying Aromas Red Sands Formation and is a major source of water for shallow wells in the Pajaro River floodplain (DWR 2003).

The Aromas Red Sands formation are considered the primary water-bearing unit of the basin and vary in thickness ranging from 100 feet near the foothills to approximately 900 feet below sea level close to the Pajaro River (DWR 2003). The water producing zones within the Aromas Red Sands formation can vary greatly in their ability to transmit water (DWR 2003).

The Purisima Formation is a thick sequence of highly variable sediments ranging from extensive shale beds near its base to continental deposits in its upper portion (DWR 2003). The thickness of this formation varies from 1,000 to 2,000 feet in the central portion of the valley to approximately 4,000 feet in the down-dropped graben between the San Andreas and Zayante-Vergales faults (DWR 2003). The sediments are chiefly poorly indurated, moderately permeable gravel, sands, silts, and silty clays. In the valley portion of the basin, the Purisima has been developed to a minor degree. Hydrologically, the most important outcrops are north and east of Pajaro Valley where this unit acts as a source of recharge to the basin (DWR 2003)

Groundwater Levels and Storage Figure 6-21 shows contour maps of groundwater levels within the Pajaro Valley for the fall of 1987, 1992 and 1998. As seen in Figure 6-21 groundwater levels in inland wells are steadily declining over time (PVWMA 2002). PVWMA's Basin Management Plan Update indicates that if drought conditions were to occur again (similar to 1987-1992), overdraft conditions would worsen and seawater intrusion rates would accelerate beyond what has been measured in the past (PVWMA 2013).

The total storage capacity of the basin is estimated to be 2 million AF above the Purisima Formation (DWR 2003). If the storage from the upper Purisima Formation is included, then the estimate of total storage capacity of the basin is 7.77 million AF (DWR 2003). Between 1964 and 1997, there has been an estimated loss of 300 TAF of freshwater storage from the basin. Approximately 200 TAF of this freshwater storage loss is due to seawater intrusion, while 100 TAF is due to conditions of chronic overdraft and resultant falling groundwater levels (DWR 2003).



Source: PVWMA 2002

Figure 6-21. Pajaro Valley Fall 1987, 1992, and 1998 Groundwater Elevation Contours

Groundwater-Related Land Subsidence No published information on land subsidence within the Pajaro Valley was available.

Groundwater Quality The greatest and most immediate threat to groundwater supplies in the Pajaro Valley is from seawater intrusion in the coastal areas. Other groundwater quality issues to be addressed include nitrate contamination and elevated boron concentrations (PVWMA 2013).

Bitterwater Valley Groundwater Basin Bitterwater Valley Groundwater Basin is comprised of several valley areas along the San Andres Rift Zone and a somewhat upland area west of the Rift Zone within the Coast Range Mountains of San Benito County. The basin is approximately 18 miles long and has a maximum width of six miles. No specific published information on groundwater resources within the basin was found.

Gilroy-Hollister Valley Groundwater Basin The Gilroy-Hollister Valley Groundwater Basin lies between the Diablo Range on the east and the Gabilan Range and the Santa Cruz Mountains to the west. The northern portion is drained toward Monterey Bay by the Pajaro River and its tributaries. The southern portion is drained by the San Benito River and its tributaries. Bulletin 118 (DWR, 2003) divides the Gilroy-Hollister Valley Groundwater Basin into four subbasins: Llagas Area, Bolsa Area, Hollister Valley and the San Juan Bautista Area. This section focuses on the southern portion of the Gilroy-Hollister Valley Groundwater Basin (Hollister subbasin) underlying SBCWD and the Llagas subbasin underlying SCVWD.

Geology, Hydrogeology, and Hydrology The Gilroy-Hollister Valley Groundwater Basin is comprised of a sedimentary sequence consisting mainly of clays, silts, sands, and gravels (DWR 2003). The basin is bound by three fault lines (Calaveras, San Andreas, and Sargent) that also form impermeable barriers to groundwater flow. The basin consists of three geologic units: Alluvium, which consists of sediment that is generally coarser near the fringes of the subbasins and finer toward the flatter central portion of the valley; Older Alluvium, which consists of deposits that are weakly consolidated interbedded gravel, sand, and mudstones; and the Panoche Formation, which consists of deposits that are consolidated, thick interbedded sand and gravels and mudstones (Bookman-Edmonston Engineering 2006 as cited in SBCWD 2010). San Benito Gravels are included in the Older Alluvium unit and constitute the main source of groundwater within the Hollister Valley subbasin.

The Llagas subbasin is geometrically similar to the Santa Clara Valley subbasin and was formed by continental deposits of unconsolidated to semi-consolidated gravel, sand, silt and clay (DWR 1981). The water bearing formation of the subbasin includes the Santa Clara Formation and the valley fill material (alluvial and alluvial fan deposits) (DWR 1981).

The Santa Clara Formation is of Plio-Pleistocene age. This formation underlies much of the valley and unconformably overlies older non-water bearing sediments (DWR 1981). It consists of fairly well consolidated clay, silt, and sand with lenses of gravel. These sediments are generally of fluvial origin with an estimated maximum thickness of 1,800 feet (DWR 1981). The lower portions of deeper wells within the subbasin likely intersect the Santa Clara Formation. Alluvial fan deposits of Holocene age occur at the margin of the valley basin. They are composed of a heterogeneous mixture of unconsolidated to semi-consolidated clay, silt, sand, and gravel usually locally partially confined (DWR 1981). The alluvial fan deposits range in thickness from 3 feet to 125 feet and overlie the Santa Clara Formation and other older non water bearing deposits (DWR 1981). A number of these wells supply water of excellent quality for irrigation and municipal purposes (DWR 1981).

Older alluvium of the Plio-Pleistocene age is distributed in the central portion of the valley from the northern boundary of the subbasin to Gilroy. It consists of unconsolidated clay, silt, and sand formed as floodplain deposits. It characteristically is identified by a dense clayey subsoil that acts as an aquitard to vertical movement of water and limits recharge potential (DWR 1981). It provides adequate yields to wells up to 100 feet in depth and water obtained from this formation is generally suitable for most uses (DWR 1981). Younger alluvium of the Holocene age occurs in the flat lying areas from Gilroy south to the basin’s southern boundary. Similarly to the older alluvium, the younger alluvium has been formed principally as a flood plain deposit but it does not have a well-defined clay subsoil. The younger alluvium has a maximum thickness of about 100 feet and generally overlies the older alluvium and alluvial fan deposits (DWR 1981). Groundwater in the younger alluvium is generally unconfined and the quality of water is acceptable for domestic purposes (DWR 1981).

Annual precipitation for the Llagas subbasin ranges from less than 16 inches in the south to more than 24 inches in the north (DWR 2003).

Groundwater Production, Levels, and Storage SCVWD manages the Llagas subbasin where groundwater is pumped within the district by major water retailers, well owners and agricultural users. Annual average groundwater pumping within the Llagas subbasin has remained fairly constant over the years. Figure 6-22 shows historic groundwater pumping from 2000 to 2009 within the subbasin.

Figure 6-19 shows the groundwater elevation in the Llagas subbasin index well (10S03E13D003). Groundwater levels remained relatively stable over the period of record with the exception of water level declines and subsequent recovery associated with the 1976-1977 and 1987-1992 drought periods. While groundwater elevations in the index well are not indicative of elevations in all wells within the subbasin it is indicative of relative changes in groundwater levels within the subbasin (SCVWD 2001).

Figure 6-23 shows the historic groundwater elevations at key wells within the Gilroy-Hollister Valley Groundwater Basin (Hollister, San Juan, Tres Pinos, Bolsa, and Pacheco Valley subbasins). The hydrographs in Figure 6-23 are generated by averaging elevations from key wells from each subbasin for each monitoring event. In general groundwater levels have remained relatively stable in most subbasins over the past five years. However, water levels in the Bolsa and Bolsa Southeast (the bottom two lines on the lower hydrograph) appear to show a more muted seasonal fluctuation in the past two years.

Natural groundwater recharge based on the long-term average for the Llagas subbasin is estimated to be 44,300 AFY (SCVWD 2001). Total facility recharge (Artificial Recharge) countywide is estimated to be 157,200 AF (SCVWD 2001). The operational storage capacity of the Llagas subbasin is estimated to be between 150,000 and 165,000 AF (SCVWD 2010). The operation storage capacity is less than the total storage capacity of the basin and accounts for available pumping capacity, avoidance of land subsidence, and problems associated with high groundwater levels.

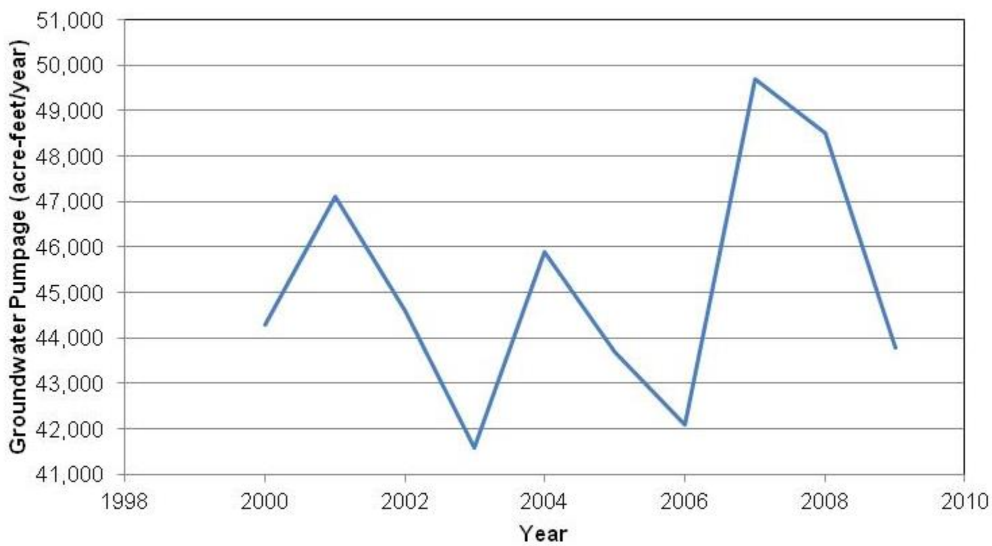
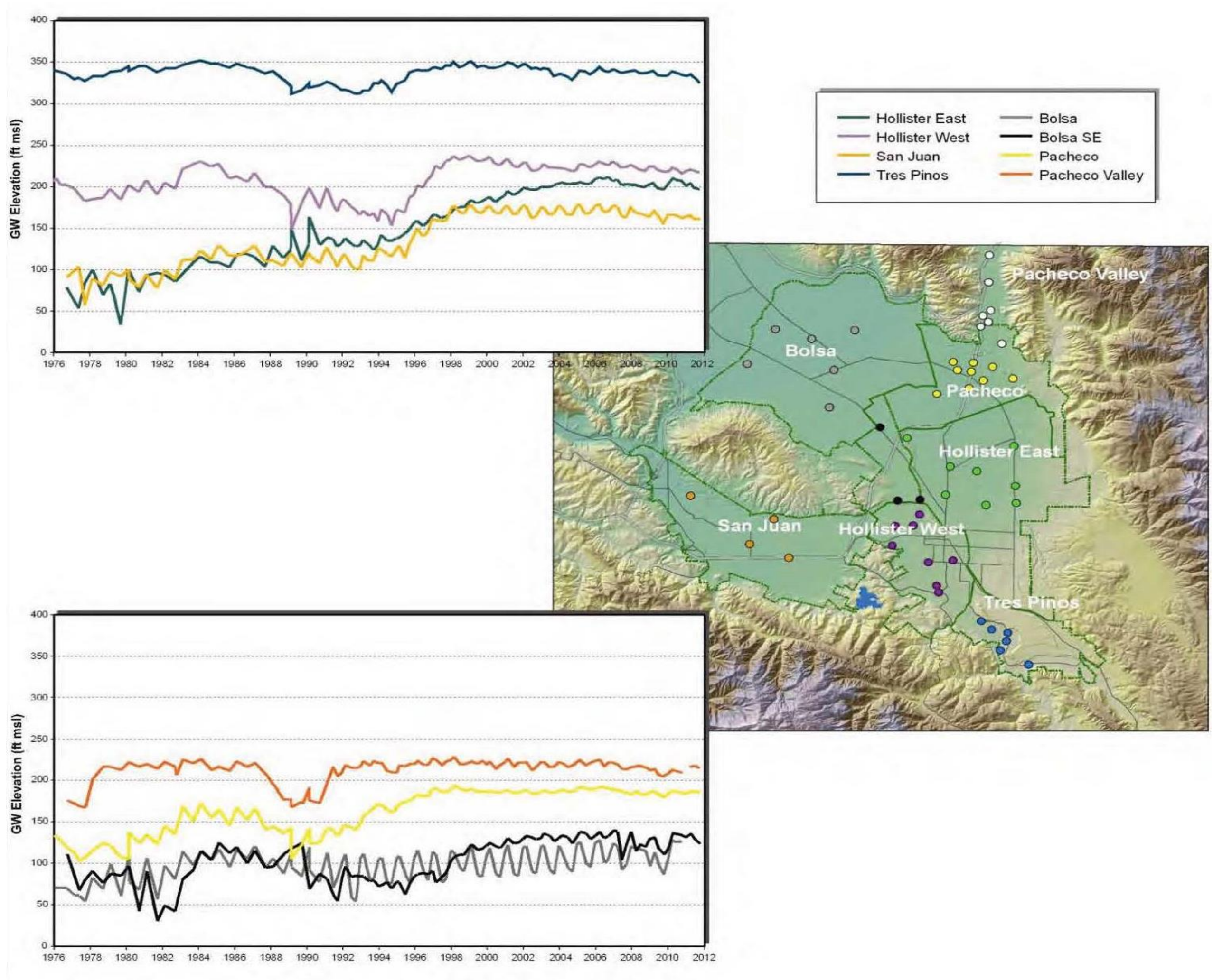


Figure 6-22. Historic Groundwater Pumping within the Llagas Subbasin



Source: SBCWD 2012

Figure 6-23. Hydrographs of Key Wells within the Gilroy-Hollister Valley Groundwater Basin

Land Subsidence Historically, Santa Clara County has experienced as much as 13 feet of subsidence caused by excessive pumping of groundwater. Most of the subsidence occurred in the Santa Clara Valley subbasin (SCVWD 2000) and it is being monitored by SCVWD.

Groundwater Quality Groundwater quality in the Gilroy-Hollister Valley Groundwater Basin is marginally acceptable for potable and irrigation use, but its levels of salinity, sodium, chloride, sulfate, nitrate, boron, arsenic, hardness, and trace elements can occasionally exceed drinking water standards (SBCWD 2010). A total of 18 monitoring wells are located throughout northern San Benito County. Water quality from the majority of these wells includes TDS concentrations exceeding 500 mg/L, the recommended limit for drinking water by DDW. Additionally, 10 of the 18 wells have TDS concentrations exceeding 1,000 mg/L, the DDW limit for drinking water, including all five wells located in the San Juan subbasin (SBCWD and SCVWD 2007 as cited in SBCWD 2010). Groundwater in the Hollister East and West subbasins also has high TDS concentrations and historically has been used as the M&I supply for SCVWD. An area of good quality water, with a TDS of less than 500 mg/L, extends from the mouth of Pacheco Creek and Arroyo de las Viboras to the west (GEI Consultants 2009 as cited in SBCWD 2010).

Almost all groundwater in the basin is hard and has a very high calcium and magnesium content. Total hardness concentrations in the groundwater have ranges from 295 to 594 mg/L as calcium carbonate (SBCWD 2010). Groundwater alkalinity in the Llagas subbasin is generally high similar to the Santa Clara Valley subbasin. Though the water is hard, it is suitable for most uses and drinking water standards are met at public supply wells without the use of treatment methods (SCVWD 2001).

SCVWD created a Nitrate Management Program in October 1991 to investigate and remediate increasing nitrate concentrations in the Llagas subbasin (SCVWD 2001). Nitrate concentrations appear to be increasing over time and elevated concentrations of nitrate still exist in the Llagas subbasin (SCVWD 2001). Since 1997, more than 600 wells in south Santa Clara County including the Llagas and Coyote subbasins have been tested for nitrate. The 2009 median nitrate concentration for the principal aquifer zone of the Llagas subbasin was 30 mg/L, with a maximum value of 155 mg/L (SCVWD 2010).

6.2 Environmental Consequences

6.2.1 Assessment Methods

This section presents the assessment methods and environmental consequences of each alternative.

Two models, CalSim II and the Statewide Agricultural Production (SWAP) model, were used in the analysis of the alternatives. Each model is briefly described below and in more detail in Appendix B, Water Operations Model Documentation, and Appendix D, Statewide Agricultural Production Model Documentation, respectively.

CalSim II is a hydrologic and operations model used by Reclamation and the DWR to conduct planning and impact analyses for the Sacramento River, San Joaquin River, and Delta. It is considered the best available tool for modeling operations of the CVP and the State Water Project (SWP). The model incorporates operating rules for the CVP and SWP that reflect a complex and extensive set of regulatory standards and operating criteria. CalSim II uses an 82-year historical period of simulation on a monthly time step. This period provides a variety of hydrologic conditions sufficient to evaluate potential impacts. It includes many different types and sequences of actual hydrologic conditions, ranging from floods to droughts of different magnitudes and durations. The CalSim II modeling provided results for changes in CVP deliveries to M&I water service contractors.

The evaluation of CVP deliveries to help meet public health and safety (PHS) needs utilizes 2030 population projections and projected 2030 demands by customer type for each contractor (where available). The future PHS ~~demand~~ need is then calculated using Reclamation's PHS formula[2]. This calculated PHS ~~demand~~ need is then compared against modeled CalSim II deliveries and, when available, data on each district's non-CVP supplies to identify any unmet PHS need. Unmet PHS needs are detailed in Chapter 4. ~~The~~ This section analyzes the potential effects to regional groundwater resources if M&I water service contractors face situations where they would need to use all of their CVP annual allocations and non-CVP supplies, including groundwater if available, to meet their PHS need. ~~choose to meet all the unmet PHS need by temporarily increasing the use of groundwater.~~ Based on the available information, it is not possible to determine how each M&I contractor would use their available supplies (i.e., CVP annual allocations and non-CVP supplies) to meet their PHS needs. Each contractor may choose to utilize supplies differently based on many factors, including those related to institutional issues and infrastructure-related concerns. The current status of each supply at the specific time of the demand may also change the methodology that each M&I contractor would use to allocate sources to meet their PHS needs. Where appropriate ~~This estimate is a~~ conservative assumptions of potential groundwater use were made, as M&I contractors may have a number of methods available to deal with water shortages. The groundwater resources described in Chapter 6.1.3 may not be available uniformly across each region.

The SWAP model is a regional agricultural production and economic optimization model that simulates the decisions of farmers. The model assumes

[2] As discussed in Chapter 2 4, PHS ~~demand~~ need = (Population * 55 gpd) + (80% of Historic/Forecasted Commercial & Institutional Demand) + (90% of Historic/Forecasted Industrial) + (10% for system losses)

that farmers maximize profit subject to resource, technical, and market constraints. The SWAP model incorporates project water supplies (SWP and CVP), other local water supplies, and groundwater. As conditions change within a SWAP region (e.g., the quantity of available project water supply increases or the cost of groundwater pumping increases), the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs. The SWAP model is used to compare the long-run response of agriculture to potential changes in SWP and CVP irrigation water delivery, other surface or groundwater conditions, or other economic values or restrictions. Results from Reclamation's and DWR's operations planning model CalSim II model are used as inputs into SWAP through a standardized data linkage tool. The SWAP modeling provided results for changes in groundwater pumping based on changes in CVP deliveries to agricultural water service contractors in three modeled regions which overlay the groundwater basins: Sacramento Valley, San Joaquin River, and Tulare Lake. The Sacramento Valley Region falls within the North of Delta geographic area, and the San Joaquin River and Tulare Lake regions fall within the South of Delta geographic area.

CalSim II and SWAP provide the projected increase in groundwater pumping under each alternative. Potential changes to groundwater levels, land subsidence, and changes in groundwater quality were assessed qualitatively. Potential effects to groundwater levels were analyzed by comparing the projected pumping between alternatives. Groundwater quality and land subsidence impacts were assessed by considering areas of known water quality/subsidence concerns and determining whether decreasing groundwater levels could detrimentally impact those areas.

6.2.2 Alternative 1: No Action

6.2.2.1 Sacramento River Region

Changes in CVP deliveries compared to existing conditions could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under the No Action Alternative, CVP deliveries to agricultural water service contractors would be lower than under existing conditions in all year types and deliveries to M&I water service contractors would be greater than existing conditions under all year types, due to changes in population growth and land use not attributable to the M&I WSP.

Table 6-2 presents the estimated ~~net~~ change in groundwater pumping under the No Action Alternative due to changes in agricultural deliveries~~ and potential groundwater use to meet unmet M&I PHS needs~~. Under the No Action Alternative, agricultural pumping in the Sacramento River Region is expected to decrease in the future. This decrease in pumping can be attributed to an increase in groundwater pumping costs in the future of approximately 17 percent, as discussed in the SWAP modeling documentation in Appendix D. In response to this substantial increase in electricity costs, farmers are expected to substitute away from groundwater pumping to other available surface water sources, or take other actions, to maximize profits. Therefore, the expected agricultural groundwater pumping in the Sacramento River Region will be lower under the No Action Alternative than existing conditions by up to 70.5 TAF as seen in Table 6-2.

As described in Chapter 4, the M&I water service contractors would experience a very small unmet PHS ~~demand~~ need in critical years under the No Action Alternative based on their anticipated combination of CVP ~~supplies~~ allocations and available non-CVP supplies. M&I groundwater pumping in 2030 is expected to increase by approximately 28 percent in Dry year types and 11 percent in Critical years compared to existing conditions (WY 2010). There will be a slight reduction in pumping during normal year types potentially due to water conservation and sustainable groundwater management practices. Increases in M&I groundwater pumping are expected to be lower than the reductions from agricultural pumping. Therefore, the No Action Alternative is expected to cause a net reduction in groundwater pumping in the Sacramento River Region.

Table 6-2. Change in Agricultural Groundwater Pumping in the Sacramento River Region between the No Action Alternative and Existing Conditions

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)~~[2]	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	-67.8	-5.4%	~~0.0~~	~~-67.8~~
Above Normal	-70.5	-5.7%	~~0.0~~	~~-70.5~~
Below Normal	-69.4	-5.5%	~~NA~~	~~NA~~
Dry	-62.1	-4.9%	~~0.0~~	~~-62.1~~
Critical	-50.1	-3.8%	~~+0.04~~	~~-50.1~~

[1] SWAP Modeling Results
~~[2] See Chapters 1 and 4 for derivation of unmet PHS need. "Below normal" years not calculated.~~
Note:
~~NA: Data not available/simulated~~
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Changes in groundwater pumping to supplement CVP supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. Groundwater pumping is expected to decrease in the future in comparison to existing conditions. Therefore, groundwater levels are not expected to decline further under the No Action Alternative. Changes in groundwater pumping under the No Action Alternative are not expected to contribute to land subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement CVP supply shortages could cause a change in groundwater quality. Under the No Action Alternative there will be a net reduction in groundwater pumping and, therefore, groundwater levels are not expected to decline further. As groundwater levels will not decrease, general groundwater flow patterns in this region are not expected to change. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

6.2.2.2 San Joaquin River Region

Changes in CVP deliveries compared to existing conditions could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under the No Action Alternative, CVP deliveries to agricultural water service contractors would be lower than under existing conditions in all year types and deliveries to M&I water service contractors would be greater than existing conditions under all year types, due to changes in population growth and land use not attributable to the M&I WSP.

Table 6-3 presents the estimated ~~net~~ change in groundwater pumping under the No Action Alternative due to changes in agricultural deliveries ~~and potential unmet M&I PHS needs~~. Similar to agricultural pumping in the Sacramento River Region, pumping in the San Joaquin Valley is expected to decrease in the future under all hydrologic year types. This decrease in pumping can be attributed to an increase in groundwater pumping costs in the future of approximately 17 percent, as discussed in the SWAP modeling documentation in Appendix D. In response to this substantial increase in electricity costs, farmers are expected to substitute away from groundwater pumping to other available surface water sources, or take other actions, to maximize profits. Therefore, the expected agricultural groundwater pumping in the San Joaquin River Region will be lower under the No Action Alternative than existing conditions by up to 50 TAF as ~~seen~~ shown in Table 6-3.

As described in Chapter 4, the M&I water service contractors would experience a small unmet PHS ~~demand~~ need under the No Action Alternative based on their anticipated combination of CVP supplies and available non-CVP supplies. ~~The small increase in groundwater pumping to meet any unmet PHS needs reported in Table 6-3 is not expected to increase the net change in groundwater pumping in the San Joaquin River Region.~~ M&I groundwater pumping in 2030 is expected to decrease by approximately 21 percent in Dry and Normal year types in comparison to existing conditions (WY 2010). These reductions in groundwater pumping could potentially be a result of water conservation and sustainable groundwater management practices within the San Joaquin Valley. The No Action Alternative is expected to cause a net reduction in groundwater pumping in the San Joaquin River Region.

Table 6-3. Change in Agricultural Groundwater Pumping in the San Joaquin River Region between the No Action Alternative and Existing Conditions

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)~~[2]	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	-48.5	-4.9%	~~+0.08~~	~~-48.4~~
Above Normal	-49.9	-4.4%	~~+0.08~~	~~-49.8~~
Below Normal	-46.2	-3.8%	~~NA~~	~~NA~~
Dry	-33.0	-2.5%	~~+0.14~~	~~-32.9~~
Critical	-6.4	-0.4%	~~+0.36~~	~~-6.0~~

[1] SWAP Modeling Results
~~[2] See Chapters 1 and 4 for derivation of unmet PHS need. "Below normal" years not calculated.~~
Note:
~~NA: Data not available/simulated~~
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Changes in groundwater pumping to supplement CVP supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. Groundwater Pumping is expected to decrease in the future in comparison to existing conditions. Therefore, groundwater levels are not expected to decline further under the No Action Alternative. Changes in groundwater pumping under the No Action Alternative are not expected to contribute to land subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement CVP supply shortages could cause a change in groundwater quality. Under the No Action Alternative there will be a net reduction in groundwater pumping and, therefore, groundwater levels are not expected to decline further. As groundwater levels will not decrease, general groundwater flow patterns in this region are not expected to change. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

6.2.2.3 Tulare Lake Region

Changes in CVP deliveries compared to existing conditions could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under the No Action Alternative, CVP deliveries to agricultural water service contractors would be lower than under existing conditions in all year types and deliveries to M&I water service contractors would be greater than existing conditions under all year types, due to changes in population growth and land use not attributable to the M&I WSP.

Table 6-4 presents the estimated net change in groundwater pumping under the No Action Alternative due to changes in agricultural deliveries ~~and potential~~

~~unmet M&I PHS needs~~. Agricultural pumping in the Tulare Lake region is expected to decrease in some year types and increase in some year types (see Table 6-4 for details). Decrease in pumping can be attributed to substantial increase in electricity costs, farmers are expected to substitute away from groundwater pumping to other available surface water sources, or take other actions, to maximize profits. Therefore, the expected agricultural groundwater pumping in the Tulare Lake Region could be lower than existing conditions by up to 30.1 TAF or higher than existing conditions up to 21.5 TAF as ~~seen~~ shown in Table 6-4.

As described in Chapter 4, the M&I water service contractors would experience some unmet PHS ~~demand~~ need under the No Action Alternative, based on their anticipated combination of CVP supplies and available non-CVP supplies. ~~As shown in Table 6-4, the net change in groundwater pumping in the Tulare Lake Region is expected to increase under the No Action Alternative due to the increase in agricultural pumping~~. M&I groundwater pumping in 2030 is expected to slightly increase (approximately one percent) in Critical and Normal year types. As described in the Existing Conditions section, groundwater levels in the Tulare Lake Region have been declining during drought periods and recovering to pre-drought levels after subsequent wet periods. Though M&I groundwater pumping is not substantial enough to cause a change in groundwater levels, ~~I~~increases in agricultural groundwater pumping in this region, particularly during the Critical hydrologic year types, up to 10~~2~~.5 TAF, could have adverse groundwater level impacts.

Table 6-4. Change in Agricultural Groundwater Pumping in the Tulare Lake Region between the No Action Alternative and Existing Conditions

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)~~[2]	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	-21.5	-0.9%	~~+0.68~~	~~-20.8~~
Above Normal	-30.1	-1.1%	~~+0.68~~	~~-29.4~~
Below Normal	+21.5	+0.7%	~~NA~~	~~NA~~
Dry	-3.7	-0.1%	~~+1.18~~	~~-2.6~~
Critical	+10.5	+0.3%	~~+1.97~~	~~+12.5~~

[1] SWAP Modeling Results
Note:
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Changes in groundwater pumping to supplement CVP supply shortages may cause groundwater level declines that could lead to land subsidence. As described in Chapter 6.1.3.2, subsidence is a serious concern in various areas of the San Joaquin Valley Groundwater Basin. The net increase in groundwater pumping under this alternative could potentially cause an increase in ~~permanent~~ land subsidence within the San Joaquin Valley Groundwater Basin.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Under this alternative there will be a net increase in groundwater pumping. Inducing the movement or migration of reduced quality water into previously unaffected areas through groundwater pumping is not likely to be a concern unless groundwater levels and/or flow patterns are substantially altered for a long period of time. Agricultural groundwater extraction under the No Action Alternative would be limited to short-term withdrawals during the irrigation season.

6.2.2.4 San Francisco Bay/Central Coast Region

Changes in CVP deliveries compared to existing conditions could cause water service contractors to supplement their water supplies through additional groundwater pumping.

Agricultural contractors in the San Francisco Bay/Central Coast Region could increase pumping under this Alternative;~~. However, there will be no unmet PHS demand for the M&I contractors in the San Francisco Bay/Central Coast Region. There could be a net increase in groundwater pumping under this alternative;~~ the amount of increase has not been quantified. M&I contractors are expected to increase their groundwater pumping by approximately 21 percent in Dry year types and 7 percent in critical years. Increases in groundwater pumping in this region, particularly during the Dry hydrologic year types, could have adverse groundwater level impacts.

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to land subsidence. Land subsidence in this region is expected to increase due to increased groundwater pumping. Land subsidence has been a serious concern in some of the groundwater basins within this region. Increase in groundwater pumping under this alternative could increase subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages could cause a change in groundwater quality. Groundwater pumping in this region is expected to increase under this alternative. Inducing the movement or migration of reduced quality water into previously unaffected areas through groundwater pumping is not likely to be a concern unless groundwater levels and/or flow patterns are substantially altered for a long period of time. As pumping is expected to increase substantially only under dry conditions, flow patterns are not expected to change substantially under Alternative 1. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

6.2.3 Alternative 2: Equal Agricultural and M&I Allocation

6.2.3.1 Sacramento River Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under Alternative 2, CVP deliveries to agricultural water service contractors would be higher than under the No Action Alternative in all year types and deliveries to M&I water service contractors would be lower than the No Action Alternative under all year types.

Table 6-5 presents the estimated ~~net~~ change in groundwater pumping under Alternative 2 due to changes in agricultural deliveries ~~and potential unmet M&I PHS needs~~. Under Alternative 2, allocations to agricultural water service contractors are higher than the allocation under the No Action Alternative. Therefore, the expected agricultural groundwater pumping in the Sacramento River Region would be lower than under the No Action Alternative, up to 5 TAF.

Under Alternative 2, CVP deliveries to M&I water service contractors ~~under Alternative 2~~ would be lower than deliveries under the No Action Alternative. Modeling results indicate some of the M&I contractors within the Sacramento River Region may use all available groundwater supplies approximately zero to two percent of the time during the CalSim II simulation period (1922 through 2003) in order to meet their PHS need using a combination of their CVP allocations and non-CVP supplies. This condition typically occurs during Critical years when CVP allocations to M&I contractors would be very low. This level of pumping, needed to meet their PHS needs in conjunction with other CVP and non-CVP supplies, would occur more frequently than under the No Action Alternative. This increase in groundwater pumping is not large enough to cause a decline in groundwater levels within the Sacramento River region. ~~As shown in Table 6-5, M&I water service contractors would experience unmet PHS demands in Alternative 2, ranging from 0.3 TAF to 1.6 TAF. M&I contractors may choose to pump additional groundwater to meet these needs. The net change in pumping under this Alternative is expected to be lower than the pumping under the No Action Alternative, up to 4.3~~4.6 ~~TAF. Therefore,~~ T~~t~~he net reduction in pumping under this alternative would not cause a decline in groundwater levels within the Sacramento River Region.

Table 6-5. Change in Agricultural Groundwater Pumping in the Sacramento River Region between Alternative 2 and the No Action Alternative

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)~~[2]	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	-3.01	-0.2%	~~+0.27~~	~~-2.74~~
Above Normal	-4.58	-0.4%	~~+0.27~~	~~-4.31~~
Below Normal	-1.28	-0.1%	~~NA~~	~~NA~~
Dry	-1.36	-0.1%	~~+0.42~~	~~-0.94~~
Critical	-3.13	-0.2%	~~+1.59~~	~~-1.54~~

[1] SWAP Modeling Results
Note:
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. Under Alternative 2, there will be a net reduction in groundwater pumping and, therefore, groundwater levels are not expected to decline further. Therefore, the changes in groundwater pumping under Alternative 2 are not expected to increase land subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages could cause a change in groundwater quality. Under Alternative 2 there will be a net reduction in groundwater pumping and, therefore, groundwater levels are not expected to decline further. As groundwater levels will not decrease, general groundwater flow patterns in this region are not expected to change. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

Idling cropland could decrease applied water recharge to the local groundwater system underlying the barren (idled) fields that could result in a decline in groundwater levels. There will be an increase in agricultural deliveries under Alternative 2 and this is not expected to increase the acreage of idled farmlands; therefore, there will be no change in applied water recharge in comparison to Alternative.

6.2.3.2 San Joaquin River Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under Alternative 2, CVP deliveries to agricultural water service contractors would be higher than under the No Action Alternative in all year types and deliveries to M&I water service contractors would be lower than the No Action Alternative under all year types.

Table 6-6 presents the estimated ~~net~~ change in groundwater pumping under Alternative 2 due to changes in agricultural deliveries ~~and potential unmet M&I PHS needs~~. Similar to allocations in the Sacramento River region, allocations to agricultural water service contractors under Alternative 2 are higher than the allocation under the No Action Alternative. Therefore, the expected agricultural groundwater pumping in the San Joaquin River Region would be lower than under the No Action Alternative, up to 35 TAF.

Under Alternative 2, CVP deliveries to M&I water service contractors would be lower than deliveries under the No Action Alternative. Modeling results indicate M&I contractors within the San Joaquin River Region may not need to use all available groundwater supplies during the CalSim II simulation period (1922 through 2003) in order to meet their PHS needs using a combination of their CVP allocations and non-CVP supplies. The net reduction in pumping under this alternative would not cause a decline in groundwater levels within the San Joaquin River Region.

~~CVP deliveries to M&I water service contractors would be lower than deliveries under the No Action Alternative. As shown in Table 6-6, there would be an increase in unmet PHS demand in Alternative 2. M&I contractors may choose to pump additional groundwater to meet this unmet demand. The increase in groundwater pumping for M&I contractors in Alternative 2 could be as high as 3.2 TAF. The net change in pumping under Alternative 2 is expected to be lower than the pumping under the No Action Alternative, up to 31.5~~35 ~~TAF. Therefore, the net reduction in pumping under this Alternative would not cause a decline in groundwater levels within the San Joaquin River Region.~~

Table 6-6. Change in Agricultural Groundwater Pumping in the San Joaquin River Region between Alternative 2 and the No Action Alternative

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)~~[2]	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	-9.52	-1.0%	~~+0.19~~	~~-9.33~~
Above Normal	-11.94	-1.1%	~~+0.19~~	~~-11.75~~
Below Normal	-17.42	-1.5%	~~NA~~	~~NA~~
Dry	-30.20	-2.3%	~~+0.74~~	~~-29.46~~
Critical	-34.78	-2.3%	~~+3.2~~	~~-31.58~~

[1] SWAP Modeling Results
Note:
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. Under Alternative 2 there will be a net reduction in groundwater pumping and, therefore, groundwater levels are not expected to decline further. Therefore, the changes in groundwater pumping under Alternative 2 are not expected to increase land subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Under Alternative 2 there will be a net reduction in groundwater pumping and, therefore, groundwater levels are not expected to decline further. As groundwater levels will not decrease, general groundwater flow patterns in this region are not expected to change. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

Idling cropland could decrease applied water recharge to the local groundwater system underlying the barren (idled) fields that could result in a decline in groundwater levels. There will be an increase in agricultural deliveries under this Alternative and this is not expected to increase the acreage of idled farmlands, therefore, there will be no change in applied water recharge in comparison to Alternative.

6.2.3.3 Tulare Lake Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under Alternative 2, CVP deliveries to agricultural water service contractors would be higher than under the No Action Alternative in all year types and deliveries to M&I water service contractors would be lower than the No Action Alternative under all year types.

Table 6-7 presents the estimated ~~net~~ change in groundwater pumping under Alternative 2 due to changes in agricultural deliveries ~~and potential unmet M&I PHS needs~~. Similar to allocations in the Sacramento and San Joaquin River Region, allocations to agricultural water service contractors under Alternative 2 are higher than the allocation under the No Action Alternative. Therefore, the expected agricultural groundwater pumping in the Tulare Lake Region would be lower than under the No Action Alternative, up to 38 TAF.

Under Alternative 2, CVP deliveries to M&I water service contractors would be lower than deliveries under the No Action Alternative. Modeling results indicate some of the M&I contractors within the Tulare Lake River Region may use all available groundwater supplies up to 10 percent of the time during the CalSim II simulation period (1922 through 2003) in order to meet their PHS needs with ~~r~~a combination of their CVP allocations and non-CVP supplies. This condition typically occurs during Critical years when CVP allocations to M&I contractors are less than or equal to 17 percent. This level of pumping, needed to meet their PHS needs in conjunction with other CVP and non-CVP supplies, would occur more frequently than under the No Action Alternative. This increase in groundwater pumping is not large enough to cause a decline in groundwater levels within the Tulare Lake River Region.

~~CVP deliveries to M&I water service contractors would be lower than deliveries under the No Action Alternative. As shown in Table 6-7, contractors would experience unmet PHS demands under Alternative 2. M&I contractors may choose to pump additional groundwater to meet this unmet demand. The increase in groundwater pumping for M&I contractors in Alternative 2 could be as high as 1.8 TAF.~~ The net change in pumping under this alternative is expected to be lower than the pumping under the No Action Alternative~~, up to 38 TAF~~. Therefore, the net reduction in pumping under this alternative would not cause a decline in groundwater levels within the Tulare Lake Region.

Table 6-7. Change in Agricultural Groundwater Pumping in the Tulare Lake Region between Alternative 2 and the No Action Alternative

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)[2]~~	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	-25.05	-1.0%	~~+0.18~~	~~-24.87~~
Above Normal	-38.02	-1.4%	~~+0.18~~	~~-37.84~~
Below Normal	-25.69	-0.9%	~~NA~~	~~NA~~
Dry	-11.97	-0.4%	~~+0.29~~	~~-11.68~~
Critical	-13.55	-0.4%	~~+1.76~~	~~-11.79~~

[1] SWAP Modeling Results
~~[2] See Chapters 1 and 4 for derivation of unmet PHS need. "Below normal" years not calculated.~~
Note:
~~NA: Data not available/simulated~~
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. Under Alternative 2 there will be a net reduction in groundwater pumping and, therefore, groundwater levels are not expected to decline further. Therefore, the changes in groundwater pumping under Alternative 2 are not expected to increase land subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Under Alternative 2 there will be a net reduction in groundwater pumping and, therefore, groundwater levels are not expected to decline further. As groundwater levels will not decrease, general groundwater flow patterns in this region are not expected to change. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

Idling cropland could decrease applied water recharge to the local groundwater system underlying the barren (idled) fields that could result in a decline in groundwater levels. There will be an increase in agricultural deliveries under this Alternative and this is not expected to increase the acreage of idled farmlands, therefore, there will be no change in applied water recharge in comparison to the No Action Alternative.

6.2.3.4 San Francisco Bay/Central Coast Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under Alternative 2, CVP deliveries to agricultural water service contractors would be higher than under the No Action Alternative in all year types and deliveries to M&I water service contractors would be lower than the No Action Alternative under all year types.

Agricultural water service contractors within the San Francisco Bay/Central Coast Region could have an increase in CVP allocations under this alternative. This increase in CVP deliveries would result in a decrease in the amount of agricultural pumping; however, the amount of reduction has not been quantified under this alternative.

~~CVP deliveries to M&I water service contractors under Alternative 2 would be lower than deliveries under the No Action Alternative. As a result, there would be an increase in unmet PHS demand, as shown in Table 6-8. M&I contractors may choose to pump additional groundwater to meet this remaining demand. As a result, there will be a net increase in pumping up to 21 TAF in this region.~~

~~Table 6-8. Change in Groundwater Pumping between Alternative 2 and the No Action Alternative within the San Francisco Bay/Central Coast Region~~

~~Hydrologic Year Type~~	~~Change in Unmet in PHS Demand (Alternative 2 vs. the No Action Alternative) (TAF)~~
~~Normal~~	~~+1.33~~
~~Dry~~	~~+20.95~~
~~Critical~~	~~+3.26~~

~~Note:~~

~~“+” sign indicates increase in pumping~~

Under Alternative 2, CVP deliveries to M&I water service contractors would be lower than deliveries under the No Action Alternative. Modeling results indicate some of the M&I contractors within the San Francisco Bay/Central Coast Region may need to use all available groundwater supplies up to 70 percent of the time during the CalSim II simulation period (1922 through 2003) in order to meet their PHS need with a combination of their CVP allocations and non-CVP supplies. This increase in groundwater pumping is approximately five percent higher than under the No Action Alternative.

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. Groundwater pumping in this region is expected to increase due to the reduction in M&I allocations. There will be a net increase in groundwater pumping and, therefore, groundwater levels are expected to decline in this region. Land Subsidence has been a serious concern in some of the groundwater basins within this region. Increase in groundwater pumping under this alternative could increase subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Groundwater pumping in this region is expected to increase due to the reduction in M&I allocations. There will be a net increase in groundwater pumping and, therefore, groundwater levels are expected to decline in this region. Inducing the movement or migration of reduced quality water into previously unaffected areas through groundwater pumping is not likely to be a concern unless groundwater levels and/or flow patterns are substantially altered for a long period of time. As pumping is expected to increase substantially only under dry conditions, flow patterns are not expected to change substantially under Alternative 2. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

Idling cropland could decrease applied water recharge to the local groundwater system underlying the barren (idled) fields that could result in a decline in groundwater levels. There will be an increase in agricultural deliveries under Alternative 2 and this is not expected to increase the acreage of idled farmlands, therefore, there will be no change in applied water recharge in comparison to the No Action Alternative.

6.2.4 Alternative 3: Full M&I Allocation Preference

6.2.4.1 Sacramento River Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under Alternative 3, M&I water service contractors would receive a 100 percent allocation as compared to the No Action Alternative and other action alternatives. This would be achieved by reducing the allocations to agricultural water service contractors as needed to maximize the frequency of ~~full~~ 100 percent allocations to the M&I water service contractors.

Table ~~6-9~~ 6-8 presents the estimated net change in groundwater pumping under Alternative 3 due to changes in agricultural deliveries ~~and potential unmet M&I PHS needs~~. Under Alternative 3, reduced allocations to agricultural water services contractors would result in agricultural water services contractors supplementing their surface water supplies through additional groundwater pumping. Therefore, the expected agricultural groundwater pumping in the Sacramento River Region would be higher than under the No Action Alternative, up to ~~2~~ two TAF.

M&I water service contractors would receive a 100 percent allocation under Alternative 3. Therefore, ~~as shown in Table 6-9,~~ there would be zero or minimal ~~unmet PHS demand~~changes to M&I groundwater pumping under Alternative 3 ~~in comparison~~as compared to the No Action Alternative. There will be a net increase in pumping under this alternative due to the increased agricultural pumping within the Sacramento River Region.

As described in the Existing Conditions section, groundwater levels in the Sacramento River Region have been declining during drought periods and recovering to pre-drought levels after subsequent wet periods. Increase in groundwater pumping in this region particularly during the Critical- hydrologic year types could have adverse groundwater level impacts.

Table 6-8. Change in Agricultural Groundwater Pumping in the Sacramento River Region between Alternative 3 and the No Action Alternative

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)~~[2]	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	+0.43	+0.1%	~~+0.00~~	~~+0.43~~
Above Normal	+1.97	+0.2%	~~+0.00~~	~~+1.97~~
Below Normal	+0.60	+0.1%	~~NA~~	~~NA~~
Dry	-0.33	-0.1%	~~+0.00~~	~~-0.33~~
Critical	+1.21	+0.1%	~~+0.03~~	~~+1.24~~

[1] SWAP Modeling Results
~~[2] See Chapters 1 and 4 for derivation of unmet PHS need. "Below normal" years not calculated.~~
Note:
~~NA: Data not available/simulated~~
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. As shown in Figure 6-10, portions of Colusa and Yolo counties have experienced historic land subsidence. ~~and i~~Increased subsidence has also been ~~noticed~~ reported at Conaway Ranch (Yolo County). Under this alternative there will be a net increase in groundwater pumping that could potentially cause an increase in ~~permanent~~ land subsidence within the Sacramento Valley.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Under this alternative there will be a net increase in groundwater pumping. Inducing the movement or migration of reduced quality water into previously unaffected areas through groundwater pumping is not likely to be a concern unless groundwater levels and/or flow patterns are substantially altered for a long period of time. Agricultural groundwater extraction under Alternative 3 would be limited to short-term withdrawals during the irrigation season.

Idling cropland could decrease applied water recharge to the local groundwater system underlying the barren (idled) fields that could result in a decline in groundwater levels. There will be a decrease in agricultural deliveries under Alternative 3. Reduced surface water supplies and increasing groundwater pumping costs could force some farmers to idle their lands. This could decrease applied water recharge and cause declines in groundwater levels within the region.

6.2.4.2 San Joaquin River Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under Alternative 3, M&I water service contractors would receive a ~~the highest deliveries~~100 percent allocation compared to the No Action Alternative and other action alternatives. This would be achieved by reducing the allocations to agricultural water service contractors as needed to maximize the frequency of ~~full~~ 100 percent allocations to the M&I water service contractors.

Table ~~6-10~~ 6-9 presents the estimated net change in groundwater pumping under Alternative 3 due to changes in agricultural deliveries~~ and potential unmet M&I PHS needs~~. Under Alternative 3, reduced allocations to agricultural water service contractors would result in agricultural water service contractors supplementing their surface water supplies through additional groundwater pumping. Therefore, the expected agricultural groundwater pumping in the San Joaquin River Region would be higher than under the No Action Alternative, up to 21 TAF.

M&I water service contractors would receive a 100 percent allocation under Alternative 3. Therefore, there would be zero or minimal changes to M&I groundwater pumping under Alternative 3 in comparison to the No Action

Alternative. ~~Therefore, as shown in Table 6-10, the unmet PHS demand under Alternative 3 will be very small in comparison to the No Action Alternative.~~ There will be a net increase in pumping under this alternative due to the increased agricultural pumping within the San Joaquin River Region.

As described in the Existing Conditions section, groundwater levels in the San Joaquin River Region have been declining during drought periods and recovering to pre-drought levels after subsequent wet periods. Increase in groundwater pumping in this region particularly during the Critical and Dry hydrologic year types could have adverse groundwater level impacts.

Table 6-9. Change in Agricultural Groundwater Pumping in the San Joaquin River Region between Alternative 3 and the No Action Alternative

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)[2]~~	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	+3.40	+0.3%	~~+0.09~~	~~+3.49~~
Above Normal	+4.29	+0.4%	~~+0.09~~	~~+4.38~~
Below Normal	+9.89	+0.8%	~~NA~~	~~NA~~
Dry	+20.64	+1.5%	~~+0.19~~	~~+20.83~~
Critical	+18.74	+1.2%	~~+0.42~~	~~+19.16~~

[1] SWAP Modeling Results
~~[2] See Chapters 1 and 4 for derivation of unmet PHS need. "Below normal" years not calculated.~~
Note:
~~NA: Data not available/simulated~~
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. As described in Chapter 6.1.3.2, subsidence is a serious concern in various areas of the San Joaquin Groundwater Basin. Under Alternative 3 there will be a net increase in groundwater pumping that could potentially cause an increase in ~~permanent~~ land subsidence within the San Joaquin Valley.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Under this alternative there will be a net increase in groundwater pumping. Inducing the movement or migration of reduced quality water into previously unaffected areas through groundwater pumping is not likely to be a concern unless groundwater levels and/or flow patterns are substantially altered for a long period of time. Agricultural groundwater extraction under Alternative 3 would be limited to short-term withdrawals during the irrigation season.

Idling cropland could decrease applied water recharge to the local groundwater system underlying the barren (idled) fields that could result in a decline in groundwater levels. There will be a decrease in agricultural deliveries under Alternative 3. Reduced surface water supplies and increasing groundwater pumping costs could force some farmers to idle their lands. This could decrease applied water recharge and cause declines in groundwater levels within the region.

6.2.4.3 Tulare Lake Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under Alternative 3, M&I water service contractors would receive a ~~the highest deliveries~~100 percent allocation compared to the No Action Alternative and other action alternatives. This would be achieved by reducing the allocations to agricultural water service contractors as needed to maximize the frequency of ~~full~~ 100 percent allocations to the M&I water service contractors.

Table ~~6-11~~ 6-10 presents the estimated net change in groundwater pumping under Alternative 3 due to changes in agricultural deliveries ~~and potential unmet M&I PHS needs~~. Under Alternative 3, reduced allocations to agricultural water service contractors would result in agricultural water service contractors supplementing their surface water supplies through additional groundwater pumping. Therefore, the expected agricultural groundwater pumping in the Tulare Lake Region would be higher than under the No Action Alternative, up to 14.5 TAF.

M&I water service contractors would receive a 100 percent allocation under Alternative 3. Therefore, there would be zero or minimal changes to M&I groundwater pumping under Alternative 3 in comparison to the No Action Alternative. ~~Therefore, as shown in Table 6-10, the unmet PHS demand under Alternative 3 will be very small in comparison to the No Action Alternative.~~

There will be a net increase in pumping under this ~~Alternative~~ alternative due to the increased agricultural pumping within the San Joaquin River Region. As described in the Existing Conditions section, groundwater levels in the Tulare Lake Region have been declining during drought periods and recovering to pre-drought levels after subsequent wet periods. Increase in groundwater pumping in this region particularly during the Critical and Dry hydrologic year types could have adverse groundwater level impacts.

Table 6-10. Change in Agricultural Groundwater Pumping in the Tulare Lake Region between Alternative 3 and the No Action Alternative

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)~~[2]	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	+10.98	+0.4%	~~+0.09~~	~~+11.07~~
Above Normal	+14.52	+0.5%	~~+0.09~~	~~+14.61~~
Below Normal	+3.11	+0.1%	~~NA~~	~~NA~~
Dry	+8.49	+0.3%	~~+0.18~~	~~+8.67~~
Critical	+7.01	+0.2%	~~+0.42~~	~~+7.43~~

[1] SWAP Modeling Results
Note:
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. As described in Chapter 6.1.3.2, subsidence appears to be a serious concern in various areas of the San Joaquin Groundwater Basin. Under this alternative there will be a net increase in groundwater pumping that could potentially cause an increase in ~~permanent~~ land subsidence within the Tulare Lake Region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Under this alternative there will be a net increase in groundwater pumping. Inducing the movement or migration of reduced quality water into previously unaffected areas through groundwater pumping is not likely to be a concern unless groundwater levels and/or flow patterns are substantially altered for a long period of time. Agricultural groundwater extraction under Alternative 3 would be limited to short-term withdrawals during the irrigation season.

Idling cropland could decrease applied water recharge to the local groundwater system underlying the barren (idled) fields that could result in a decline in groundwater levels. There will be a decrease in agricultural deliveries under Alternative 3. Reduced surface water supplies and increasing groundwater pumping costs could force some farmers to idle their lands. This could decrease applied water recharge and cause declines in groundwater levels within the region.

6.2.4.4 San Francisco Bay/Central Coast Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Under Alternative 3, M&I water service contractors would receive ~~the highest deliveries~~a 100 percent allocation compared to the No

Action Alternative and other action alternatives. This would be achieved by reducing the allocations to agricultural water service contractors as needed to maximize the frequency of 100 percent~~full~~ allocations to the M&I water service contractors.

Agricultural water service contractors within the San Francisco Bay/Central Coast Region could supplement their supply shortages through groundwater pumping. The amount of increase in agricultural pumping has not been quantified under this alternative. M&I allocations will be higher than the allocation under the No Action Alternative.

~~Hydrologic Year Type~~	~~Change in Unmet in PHS Demand (Alternative 2 – the No Action Alternative) (TAF)~~
~~Normal~~	~~-1.0~~
~~Dry~~	~~-0.6~~
~~Critical~~	~~-1.5~~

~~Note:~~

~~“-“ sign indicates decrease in pumping~~

6.2.5 Alternative 4: Updated M&I WSP

Under Alternative 4, there will be no change in water supply deliveries to agricultural and M&I contractors within the Sacramento River, San Joaquin Valley, Tulare Lake, and San Francisco Bay/Central Coast regions compared to the No Action Alternative. Allocations under Alternative 4 will be similar to those under the No Action Alternative. Therefore, groundwater effects generated by Alternative 4 would be identical to the effects under the No Action Alternative.

6.2.6 Alternative 5: M&I Contractor Suggested WSP

6.2.6.1 Sacramento River Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Alternative 5 provides an increased quantity ~~a greater level~~ of ~~assurance that~~ CVP water ~~will be allocated~~ to M&I water service contractors to supply the unmet portion of the PHS ~~demands~~ needs during ~~shortage years~~a Condition of Shortage. This distribution will result in reduced allocations to agricultural water service contractors.

Table ~~6-13~~ 6-11 presents the estimated net change in groundwater pumping under Alternative 5 due to changes in agricultural deliveries ~~and potential unmet M&I PHS needs~~. Under Alternative 5, reduced allocations to agricultural water service contractors would result in agricultural water service contractors supplementing their surface water supplies through additional groundwater pumping. As shown in Table ~~6-13~~ 6-11, the expected increase in groundwater pumping will be very small and will not cause any adverse impacts to groundwater levels in the Sacramento River Region.

Table 6-11. Change in Agricultural Groundwater Pumping in the Sacramento River Region between Alternative 5 and the No Action Alternative

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)[2]~~	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	0.00	~0.0%	~~0.00~~	~~0.00~~
Above Normal	+0.02	~0.0%	~~0.00~~	~~+0.02~~
Below Normal	0.00	~0.0%	~~NA~~	~~NA~~
Dry	+0.11	~0.0%	~~0.00~~	~~+0.11~~
Critical	+0.01	~0.0%	~~0.00~~	~~+0.01~~

[1] SWAP Modeling Results
~~[2] See Chapters 1 and 4 for derivation of unmet PHS need. "Below normal" years not calculated.~~
Note
~~NA: Data not available/simulated~~
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. Under Alternative 5, there will be a very small (up to 110 AF) net increase in groundwater pumping; therefore, groundwater levels are not expected to decline substantially. Therefore, the changes in groundwater pumping under Alternative 5 are not expected to increase land subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Under Alternative 5, there will be a very small (up to 110 AF) net increase in groundwater pumping; therefore, groundwater levels are not expected to decline substantially. As groundwater levels will not decrease, general groundwater flow patterns in this region are not expected to change. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

6.2.6.2 San Joaquin River Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Alternative 5 provides an increased quantity ~~a greater~~

~~level~~ of ~~assurance that~~ CVP water ~~will be allocated~~ to M&I water service contractors to supply the unmet portion of the PHS ~~demands~~ needs during ~~shortage years~~a Condition of Shortage. This distribution will result in reduced allocations to agricultural water service contractors.

Table ~~6-14~~ 6-12 presents the estimated net change in groundwater pumping under Alternative 5 due to changes in agricultural deliveries~~ and potential unmet M&I PHS needs. As shown in Table 6-14, the unmet PHS demand under Alternative 5 will be very small and there will be very small increase in agricultural pumping~~. The net change in groundwater pumping in the San Joaquin River Region would be very small (up to 80~~0~~ AF) and is not expected to cause adverse effects to groundwater levels in the San Joaquin River Region.

Table 6-12. Change in Agricultural Groundwater Pumping in the San Joaquin River Region between Alternative 5 and the No Action Alternative

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)[2]~~	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	+0.03	~0.0%	~~+0.17~~	~~+0.20~~
Above Normal	+0.07	~0.0%	~~+0.17~~	~~+0.24~~
Below Normal	-0.01	~0.0%	~~NA~~	~~NA~~
Dry	+0.08	~0.0%	~~+0.29~~	~~+0.37~~
Critical	+0.06	~0.0%	~~+0.74~~	~~+0.80~~

[1] SWAP Modeling Results
Note
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. Under this alternative there will be a very small (up to 80~~0~~ AF) net increase in groundwater pumping therefore, groundwater levels are not expected to decline substantially. Therefore, the changes in groundwater pumping under Alternative 5 are not expected to increase land subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Under Alternative 5, there will be a very small (up to 80~~0~~ AF) net increase in groundwater pumping; therefore, groundwater levels are not expected to decline substantially. As groundwater levels will not decrease, general groundwater flow patterns in this region are not expected to change. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

6.2.6.3 Tulare Lake Region

Changes in CVP deliveries compared to the No Action Alternative could cause water service contractors to supplement their water supplies through additional groundwater pumping. Alternative 5 provides ~~a greater level~~an increased quantity of ~~assurance that~~ CVP water ~~will be allocated~~ to M&I water service contractors to supply the unmet portion of the PHS ~~demands~~ needs during a Condition of Shortage~~shortage years~~. This will result in reduced allocations to agricultural water service contractors.

Table ~~6-15~~ 6-13 presents the estimated net change in groundwater pumping under Alternative 5 due to changes in agricultural deliveries and potential unmet M&I PHS needs. As shown in Table ~~6-15~~ 6-13, there would be ~~no unmet PHS demand under this Alternative and~~ a very small increase in agricultural pumping. The net change in groundwater pumping in the Tulare Lake Region would be very small and is not expected to cause adverse effects to groundwater levels in the Tulare Lake Region.

Table 6-13. Change in Agricultural Groundwater Pumping in the Tulare Lake Region between Alternative 5 and the No Action Alternative

Hydrologic Year Type	Change in Agricultural Groundwater Pumping[1]		~~Maximum Change in M&I Groundwater Pumping (Unmet PHS Need)[2]~~	~~Net Change in Groundwater Pumping~~
	TAF	Percent change	~~TAF~~	~~TAF~~
Wet	+0.18	~0.0%	~~0.00~~	~~+0.18~~
Above Normal	+0.59	~0.0%	~~0.00~~	~~+0.59~~
Below Normal	+0.08	~0.0%	~~NA~~	~~NA~~
Dry	+0.03	~0.0%	~~0.00~~	~~+0.03~~
Critical	+0.01	~0.0%	~~0.00~~	~~+0.01~~

[1] SWAP Modeling Results
Note
"+" sign indicates increase in pumping
"-" sign indicates decrease in pumping

Increased groundwater pumping to supplement supply shortages may cause groundwater level declines that could lead to ~~permanent~~ land subsidence. Under this alternative there will be a very small (up to 600 AF) net increase in groundwater pumping thus, groundwater levels are not expected to decline substantially. Therefore, the changes in groundwater pumping under Alternative 5 are not expected to increase land subsidence in this region.

Changes in groundwater levels or in the prevailing groundwater flow regime due to increased pumping to supplement supply shortages, could cause a change in groundwater quality. Under Alternative 5, there will be a very small (up to 600 AF) net increase in groundwater pumping; therefore, groundwater levels are not expected to decline substantially. As groundwater levels will not decrease, general groundwater flow patterns in this region are not expected to change. Groundwater quality, therefore, is not expected to change due to changes in flow patterns.

6.2.3.4 San Francisco Bay/Central Coast Region

Alternative 5 provides ~~a greater level~~an increased quantity of ~~assurance that~~ CVP water ~~will be allocated~~ to M&I water service contractors to supply the unmet portion of the PHS ~~demands~~ needs during a Condition of Shortage~~shortage years~~. This distribution will result in slightly reduced allocations to agricultural water service contractors. Agricultural water service contractors could supplement their surface water supplies through groundwater pumping. This increased groundwater pumping could result in temporary groundwater level declines. Pajaro Valley is the only agricultural contractor within the San Francisco Bay/Central Coast Region and they could increase their pumping to meet agricultural demands under this alternative. ~~PHS demands will be completely met within this region as shown in Table 6-16.~~

~~Table 6-16. Change in Groundwater Pumping between Alternative 5 and Alternative within the San Francisco Bay/Central Coast Region~~

~~Hydrologic Year Type~~	~~Change in Unmet in PHS Demand (Alternative 5 vs. No Action Alternative) (TAF)~~
~~Normal Condition~~	~~+0.0~~
~~Dry Condition~~	~~+0.0~~
~~Critical Condition~~	~~+0.0~~

6.3 Mitigation Measures

There are no mitigation measures needed to reduce the severity of the groundwater impacts.

6.4 Unavoidable Adverse Impacts

As noted in Chapter 6.2, under Alternative 3 there will be a substantial increase in groundwater pumping in the Sacramento River, San Joaquin River, and Tulare Lake regions. This increase in pumping is expected to decrease groundwater levels and could potentially cause land subsidence within these regions.

6.5 Cumulative Impacts

The timeframe for the groundwater resources cumulative effects analysis extends from 2010 through 2030, a twenty year period. The cumulative effects area of analysis for groundwater resources is the same area described in Chapter 6.1.1.

This section analyzes the cumulative effects using the project method, which is further described in Chapter 20, Cumulative Effects Methodology. Chapter 20 describes the projects included in the cumulative condition. Growth and development trends in the area of analysis are factored into the PHS ~~demand~~ needs evaluation completed in Chapter 4.2 and this cumulative analysis.

The following sections describe potential groundwater resources cumulative effects for each of the proposed alternatives.

6.5.1 Alternative 2: Equal Agricultural and M&I Allocation

Equal allocation of available CVP water supplies between M&I and agricultural water service contractors under Alternative 2 would result in increased water supply deliveries to agricultural water service contractors, and increased unmet M&I demand in the Sacramento River, San Joaquin River, Tulare Lake, and San Francisco Bay/Central Coast Regions. M&I and agricultural water service contractors could supplement their surface water supplies through groundwater pumping. This increased groundwater pumping could result in temporary groundwater level declines.

In addition to groundwater pumping that would occur by M&I and agricultural water service contractors to supplement their surface water supplies, annual groundwater substitution transfers could occur in the Sacramento Valley Groundwater Basin, as analyzed in the Long-Term Water Transfers (LTWT) Environmental Impact Statement/Environmental Impact Report (EIS/EIR), which is included in the area of analysis for Alternative 2. Reclamation's LTWT program would occur between 2015 through 2024. It is possible that groundwater substitution transfers under the LTWT program would compound the declines in groundwater levels in the Sacramento Valley Groundwater Basin.

The Northern Sacramento Valley Integrated Regional Water Management Plan is a project that aims to provide a regional perspective to planning for water use in the northern Sacramento Valley, including Butte, Colusa, Glenn, Shasta, Sutter, and Tehama counties. The Plan is still under development; however, it is expected that the Plan will help to provide management objectives that would be protective of the groundwater resources in the northern Sacramento Valley.

The Tuscan Aquifer Investigation project, conducted by the Butte County Department of Water and Resource Conservation, included numerous field data collection activities to allow for a more complete understanding of the Tuscan Aquifer. This project included the drilling of groundwater monitoring wells and the gaging of several streams in the Sierra Nevada foothills. Aquifer testing (i.e., pumping tests) was also performed at three existing production wells. The pumping associated with this project has been completed and would not contribute to cumulative effects. Information collection was primarily within Butte County, but the information about the Tuscan Aquifer could provide useful information about aquifer properties to other counties overlying the same aquifer (Glenn, Colusa, and Tehama counties).

The increased pumping under this Alternative in combination with other cumulative projects could cause land subsidence. The groundwater substitution pumping associated with the LTWT program would occur in an area that is historically not subject to significant land subsidence. In the overall area of analysis, land subsidence is occurring in several areas, as described in Chapter 6.1.3. This subsidence would not likely result in substantial risk to life or property; however, the existing subsidence along with future increases in groundwater pumping in the cumulative condition could affect life or property within the area of analysis.

The increased pumping under this Alternative in combination with other cumulative projects could cause the movement or mobilization of poorer quality groundwater into existing wells. Groundwater substitution transfers by SWP contractors and the Tuscan Aquifer Investigation Project would increase pumping within (or near) the Sacramento River Region. However, as discussed in Chapter 6.1.3.1, most of this region has high quality groundwater and changes in groundwater flow patterns should not cause migration of poor quality groundwater.

6.5.2 Alternative 3: Full M&I Allocation Preference

The cumulative impacts of Alternative 3 would be the same as described for groundwater pumping under Alternative 2.

6.5.3 Alternative 4: Updated M&I WSP

The cumulative impacts of Alternative 4 would be the same as described for groundwater pumping under Alternative 2.

6.5.4 Alternative 5: M&I Contractor Suggested WSP

The cumulative impacts of Alternative 5 would be the same as described for groundwater pumping under Alternative 2.

6.6 References

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