Long-Term Operation – Final Environmental Impact Statement

Appendix I – Groundwater Technical Appendix

November 2024

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Appendix I Groundwater Technical Appendix

This appendix documents the groundwater technical analysis to support the impact analysis in the environmental impact statement (EIS).

I.1 Background Information

Groundwater occurs throughout the study area. However, the groundwater resources that could be directly or indirectly affected through the implementation of the alternatives analyzed in the EIS are related to groundwater basins (GWBs), which include users of Central Valley Project (CVP) and State Water Project (SWP) water supplies that also use groundwater, and areas along the rivers downstream of CVP or SWP reservoirs that use groundwater supplies. Therefore, the following descriptions are limited to these areas and do not include GWBs or subbasins (GWSBs) that are not directly or indirectly affected by changes in CVP and SWP operations. Because of changes in CVP and SWP operations, changes in groundwater resources may occur in the Trinity River, Sacramento Valley (Sacramento River, American River), Clear Creek, San Joaquin Valley (Stanislaus River, San Joaquin River), and Sacramento–San Joaquin Delta (Delta) areas. The additional areas where CVP and SWP deliveries are exported (Central Coast and Southern California regions) are also included.

I.1.1 Overview

Groundwater is a vital resource in California and supplied about 37% of the state's average agricultural, municipal, and industrial water needs between 1998 and 2010, and 40% or more during dry and critical water years in that period (California Department of Water Resources 2013). About 20% of the nation's groundwater demand is supplied from the Central Valley aquifers, making it the second-most-pumped aquifer system in the United States (U.S. Geological Survey 2009). The three Central Valley hydrologic regions (Tulare Lake, San Joaquin River, and Sacramento River) account for about 75% of the state's average annual groundwater use (California Department of Water Resources 2013).

The California Department of Water Resources (DWR) has delineated distinct groundwater systems throughout the state, as described in Bulletin 118 (California Department of Water Resources 2019, 2021a), that are the most important GWBs. These GWBs and GWSBs have various degrees of supply reliability considering yield, storage capacity, and water quality and are typically alluvial, or nonconsolidated (nonfractured rock) aquifers. Through the Sustainable Groundwater Management Act (SGMA), DWR accepted applications to modify the delineation of GWBs if enough newer information was available. DWR finalized the basin boundaries and prioritization in 2019 (California Department of Water Resources 2020). The GWB descriptions provided in this appendix are primarily based on the information provided in DWR Bulletin 118.

DWR developed a priority ranking for the GWBs and GWSBs as part of the 2009 Comprehensive Water package. The priority rankings were released in 2014 as part of the California Statewide Groundwater Elevation Monitoring Program. The SGMA legislation that went into effect in 2015 required DWR to reassess the basin prioritization. Basins were prioritized based on eight factors: population, population growth, public supply wells in the basin, total wells in the basin, acres of irrigated agriculture, reliance on groundwater as a primarily supply source, documented impacts to groundwater (overdraft, subsidence, saline intrusion, water quality issues) and "other" factors (such as habitat and streamflow). DWR developed four prioritization categories by weighing these factors: high, medium, low, and very low priority. Some GWBs have been designated with a "with overdraft" indication to designate that they are on a faster track towards developing Groundwater Sustainability Plans (GSP) under SGMA. Of the 517 GWBs evaluated statewide, DWR identified 109 as high- and medium-priority basins. These high- and medium-priority basins account for approximately 98% of the groundwater use in California.

The importance of groundwater as a resource varies regionally. The Central Coast has the most reliance on groundwater to meet its local uses, with nearly 90% of the agricultural, municipal, and industrial water supplies by groundwater in an average year. The Sacramento Valley and northern portion of the San Joaquin Valley GWB use groundwater to meet approximately 34% and 48% of the agricultural, municipal, and industrial water demand, respectively (California Department of Water Resources 2021b). On an annual average basis in the coastal areas of Southern California, groundwater use varies from less than 10% in western San Diego County to between 35% and 50% of the agricultural, municipal, and industrial water supplies in counties along the coast in western Ventura, Los Angeles, and Riverside counties and in Orange County. In the inland areas of Southern California, groundwater use varies from approximately 45% to over 90% of the agricultural, municipal, and industrial water supplies (California Department of Water Resources 2015).

I.1.2 Trinity River

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River and along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

Most usable groundwater in the Trinity River Region occurs in widely scattered alluvium-filled valleys, such as those immediately adjacent to the Trinity River. These valleys contain only small quantities of recoverable groundwater and therefore are not considered a major source. A number of shallow wells adjacent to the river provide water for domestic purposes (Bureau of Reclamation et al. 2006; North Coast Regional Water Quality Control Board and Bureau of Reclamation 2009). Groundwater present in these alluvial valleys is in close hydraulic connection with the Trinity River and its tributaries. Both groundwater discharge to surface streams and leakage of steam flow to underlying aquifers are expected to occur at various locations.

DWR identified only two GWBs underlying the Trinity River Region in the action area, Hoopa Valley, and Lower Klamath River Valley GWBs (California Department of Water Resources 2004, 2021a). These GWBs are small, isolated, valley-fill aquifers that provide a limited quantity of groundwater to satisfy local domestic, municipal, and agricultural needs. Groundwater pumped from these aquifer systems is used strictly for local supply.

Several communities use infiltration galleries along the Trinity River and the tributaries to convey surface water to groundwater wells, including the Lewiston Community Services District, Lewiston Valley Water Company, and Lewiston Park Mutual Water Company (North Coast Regional Water Quality Control Board and Bureau of Reclamation 2009).

Groundwater within the Hoopa Valley Indian Reservation occurs along alluvial terraces (Hoopa Valley Tribe 2008). The aquifers are approximately 10 to 80 feet deep. Some of the shallow wells are productive only during winter and early spring months.

The Lower Klamath River Valley GWB extends over 7,030 acres in Del Norte and Humboldt counties, including areas along the Lower Klamath River (Bureau of Reclamation 2010). Groundwater along the Lower Klamath River occurs in alluvial fans near the confluences of major tributaries and along terrace and floodplain deposits adjacent to the river (Yurok Tribe 2012). The aquifers range in depth from 10 to 80 feet and are used by some members of the community.

Both the Hoopa Valley and Lower Klamath River Valley GWBs were designated by DWR as very low priority under SGMA (California Department of Water Resources 2020).

Groundwater quality is suitable for many beneficial uses in the region. In other locations, groundwater can include naturally occurring metals, including manganese, cadmium, zinc, and barium (Hoopa Valley Tribe 2008). Other groundwater quality issues include nitrate contamination (California Department of Water Resources 2015). Groundwater and surface water contamination is suspected at several former and existing mill sites that historically used wood treatment chemicals. Discharges of pentachlorophenol, polychlorodibenzodioxins, and polychlorodibenzofurans have likely occurred because of poor containment practices typically used in historical wood treatment applications. Additional investigation, sampling and monitoring, and enforcement actions have been limited by the insufficient resources that exist to address this historical toxic chemical problem (North Coast Regional Water Quality Control Board 2005).

I.1.3 Sacramento River Valley

The Sacramento Valley includes the Redding Area GWB and the Sacramento Valley GWB. The Sacramento Valley GWB is one of the largest GWBs in the state and extends from Redding in the north to the Delta in the south (U.S. Geological Survey 2009).

Approximately one-third of the Sacramento Valley's urban and agricultural water needs are met by groundwater (California Department of Water Resources 2003). The portion of the water diverted for irrigation but not actually consumed by crops or other vegetation, or evaporation directly, becomes recharge to the groundwater aquifer or flows back to surface waterways.

Overall, the Sacramento Valley GWB is approximately balanced with respect to annual recharge and pumping demand. However, there are several locations showing early signs of persistent drawdown, suggesting limitations because of increased groundwater use in dry years. Locations of persistent drawdown include Glenn County, areas near Chico in Butte County, northern Sacramento County, and portions of Yolo County.

The water quality of groundwater in the Sacramento Valley is generally good. Several areas have localized aquifers with high nitrate, total dissolved solids (TDS), or boron concentrations. High nitrate concentrations frequently occur because of residuals from agricultural operations or septic systems. High TDS, a measure of salinity, concentration can be an indicator of brackish or connate water when it occurs in high concentrations. High boron concentration usually is associated with naturally occurring deposits but can also be a marker for effects of wastewater discharge.

The groundwater conditions in areas surrounding the major rivers in the Sacramento Valley, including the Sacramento, Feather, and American rivers, are described in the subsequent sections. The descriptions of these areas are combined in this section as they all cover the Sacramento Valley GWB.

I.1.3.1 Overview of Groundwater Basins in the Sacramento Valley

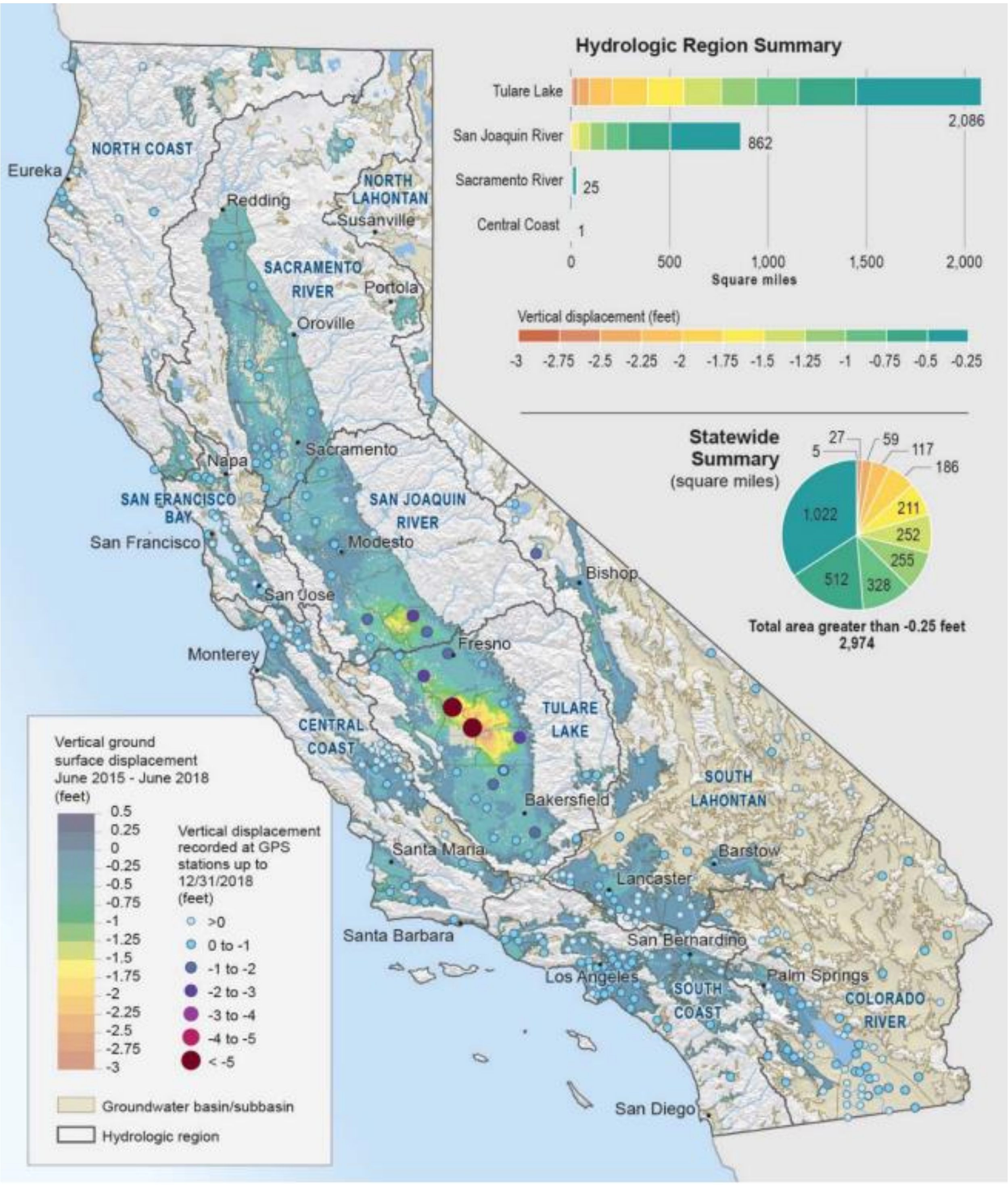
The Sacramento Valley GWB has been divided into 17 GWSBs by DWR. However, from a hydrologic standpoint, these individual GWSBs have a high degree of hydraulic connection because the rivers do not always act as barriers to groundwater flow. Therefore, the Sacramento Valley GWB functions primarily as a single laterally extensive alluvial aquifer rather than numerous discrete, smaller GWSBs. The Redding Area GWB is situated in the extreme northern end of the valley and is a separate, isolated GWB but is discussed as part of the overall Sacramento Valley because of similarities in geology and stratigraphy. This GWB is subdivided into six GWSBs by DWR. The basin is bordered by the Coast Ranges on the west and by the Cascade Range and Sierra Nevada mountains on the east.

For discussion purposes and because of their common characteristics, the Sacramento Valley is further subdivided into the Upper Sacramento Valley, the Lower Sacramento Valley west of the Sacramento River, and the Lower Sacramento Valley east of the Sacramento River.

Fresh water in the Sacramento Valley GWB generally occurs within continental deposits. Hydrogeologic units containing fresh water along the eastern portion of the basin primarily occur in the Tuscan and Mehrten formations and are derived from the Sierra Nevada. Toward the southeastern portion of the Sacramento Valley, the Mehrten formation is overlain by sediments of the Laguna, Riverbank, and Modesto formations, which also originated in the Sierra Nevada. The primary hydrogeologic unit in the western portion of the Sacramento Valley is the Tehama formation, which was derived from the Coast Ranges. In most of the Sacramento Valley, these deeper units are overlain by younger alluvial and floodplain deposits. Generally, groundwater flows inward from the edges of the basin toward the Sacramento River, then in a southerly direction parallel to the river. Depth to groundwater throughout most of the Sacramento Valley averages about 30 feet below the ground surface, with shallower depths along the Sacramento River and greater depths along the basin margins. Wells developed in the sediments of the valley provide excellent supply to irrigation, municipal, and domestic uses. The deepest elevation of the base of fresh water in the Sacramento Valley ranges between 400 and 3,350 feet below mean sea level (Berkstresser 1973). The location where the base of fresh water is the deepest occurs in the Delta near Rio Vista. Near the valley margins and the Sutter Buttes, the base of fresh water is relatively shallow, suggesting that the base of fresh water may coincide with bedrock or connate water trapped in shallower deposits close to the basin margins (Berkstresser 1973).

Groundwater levels are generally in balance across the Sacramento Valley, with pumping matched by recharge from the various sources annually. Some locales show early signs of persistent drawdown, especially in areas where water demands are met primarily—and in some locales exclusively—by groundwater. These areas include portions of the far west side of the Sacramento Valley in Glenn County, portions of Butte County near Chico, portions of Yolo County, and in the northern Sacramento County area. The persistent areas of drawdown could be early signs that the limits of sustainable groundwater use have been reached in these areas. As a result of the 2011-2016 and 2020-2022 droughts, surface water supplies declined, and new wells have been installed. Between January and October 2014, over 100 water supply wells were drilled in both Shasta and Butte counties (California Department of Water Resources 2014a). Statewide, the number of approved well permits increased from 731 to 2,005 between 2015 to 2021. The number of approved permits decreased to 1,514 in 2022 (California Department of Water Resources 2024). In general, periods of drought cause an increased reliance on groundwater.

Land subsidence in the Sacramento Valley has resulted from inelastic deformation (nonrecoverable changes) of fine-grained sediments related to groundwater withdrawal. Areas of subsidence from groundwater level declines have been measured in the Sacramento Valley at several locations (California Department of Water Resources 2018). Subsidence monitoring was established following several studies in the 1990s that indicated more than 4 feet of subsidence since 1954 in some areas, such as in Yolo County (Ikehara 1994). Initial data from the Yolo County extensometers indicated subsidence in the Zamora area, which has subsequently been confirmed with a countywide global positioning system network installed in 1999 and monitored in 2002 and 2005. Subsidence up to 0.4 foot occurred between 1999 and 2005 in the Zamora area (Frame Surveying and Mapping 2006). The Zamora area does not currently use CVP or SWP water supplies. However, this area was designated as part of the CVP Sacramento Valley Irrigation Canals service area in the Reclamation Act of 1950 and as amended in the Reclamation Act of 1980 and Central Valley Project Improvement Act. Figure I-1 shows the measured subsidence in the Sacramento Valley from 2015 to 2018 (California Department of Water Resources 2021a). There are areas on the west side of the valley near Arbuckle and Zamora/Woodland that have seen subsidence of 0.2 feet or more since 2021 (California Department of Water Resources 2023).



Source: California Department of Water Resources 2021a.

Figure I-1. Measured Subsidence, 2015 to 2018

I.1.3.2 Upper Sacramento Valley

The Upper Sacramento Valley includes the Redding Area GWB and upper portions of the Sacramento Valley GWB (California Department of Water Resources 2003). The Redding Area GWB extends from approximately Redding in Shasta County through the northern portions of Tehama County. The portions of the Sacramento Valley GWB in the Upper Sacramento Valley are located primarily in Tehama County, with small portions extending into Glenn County near Orland and Butte County near Chico in the south. The geology of this area is dominated by the Tuscan and Tehama formations. The hydrology of this area is dominated by numerous smaller drainages that originate in the Sierra Nevada, Cascade, and Coast Ranges and drain to the Sacramento River (California Department of Water Resources 2003).

Hydrogeology and Groundwater Conditions

The Redding Area GWB comprises the northernmost part of the Sacramento Valley and is bordered by the Klamath Mountains to the north, the Coast Ranges to the west, the Cascade Mountains to the east, and the Red Bluff Arch to the south. This basin consists of a sediment-filled, symmetrical, southward-dipping trough formed by folding of the marine sedimentary basement rock. These deposits are overlain by a thick sequence of interbedded, continentally derived, sedimentary and volcanic deposits of Late Tertiary and Quaternary age. The primary fresh water-bearing deposits in the basin are the Pliocene age volcanic deposits of the Tuscan formation and the Pliocene age continental deposits of the Tehama formation (California Department of Water Resources 2003, 2004).

The Tehama formation consists of unconsolidated to moderately consolidated coarse and fine-grained sediments derived from the Coast Ranges to the west. The Tehama formation is up to 4,000 feet thick and varies in depth from a few feet to several hundred feet below the land surface, with depth generally increasing to the east toward the Sacramento River (California Department of Water Resources 2003, 2004). The Tuscan formation is derived from the Cascade Range to the east and primarily composed of volcaniclastic sediments.

The Redding Area GWB includes five GWSBs: Anderson, Bowman, Enterprise, Millville, and South Battle Creek (California Department of Water Resources 2021a). The Anderson GWSB is one of the main groundwater units in the Redding Basin. Groundwater levels in the unconfined and confined portions of the aquifer system fluctuate annually by 2 to 4 feet during normal precipitation years and up to 10 to 16 feet during drought years (California Department of Water Resources 2003). Information indicates that groundwater levels declined at multiple wells by 10 feet and more between fall 2018 and fall 2021 in the Redding Area GWB. Many wells experienced changes over this period of ± 2.5 feet (California Department of Water Resources 2023). The groundwater levels in some areas declined by 10 feet and more between fall 2018 and fall 2021, with many wells recording changes of ± 2.5 feet (California Department of Water Resources 2023).

Tehama County overlies three GWSBs within the Redding Area GWB and seven GWSBs in the Sacramento Valley GWB. The Rosewood, South Battle Creek, and Bowman GWSBs in the Redding Area GWB are located in Tehama County. The Red Bluff, Corning, Bend, Antelope, Dye Creek, Los Molinos, and Vina GWSBs in the Sacramento Valley GWB are located in Tehama County (California Department of Water Resources 2004, 2006). The Corning GWSB extends into northern Glenn County near Orland. The Vina GWSB extends into northern Butte County near Chico. Groundwater levels in these GWSBs show a substantial seasonal variation because of high groundwater use for irrigation during the summer months. Groundwater levels showed substantial declines in some wells associated with the 1976 to 1977 and 1987 to 1992 drought periods. Groundwater levels appeared to recover quickly during subsequent wet years. Groundwater levels in the Corning area of Tehama County showed a general decline before 1965 because of increased groundwater pumping for agricultural uses. Following construction by the CVP of the Tehama Colusa Canal and the Corning Canal, surface water was delivered to these areas and there was a subsequent upward trend in groundwater levels following initial operations (Tehama County Flood Control and Water Conservation District 1996). Information indicates that groundwater levels in the upper portion of the Sacramento Valley GWB declined at multiple wells approximately 2.5 to 10 feet, with few decreases of over 10 feet, between fall 2018 and fall 2021 (California Department of Water Resources 2023). Groundwater quality in the Redding Area GWB is generally good to excellent for most uses. Some areas of poor quality because of high salinity from marine sedimentary rock exist at the margins of the basin. Portions of the basin are characterized by high boron, iron, manganese, and nitrates in localized areas (California Department of Water Resources 2004). In general, groundwater in the Sacramento Valley GWB within Tehama County is of excellent quality, with some localized areas with groundwater quality concerns related to boron, calcium, chloride, magnesium, nitrate, phosphorous, and TDS (California Department of Water Resources 2004, 2006). In the vicinity of Antelope, east of Red Bluff, historical high nitrates in groundwater occur. Higher boron levels have been detected in wells located in the eastern portion of Tehama County. High salinity occurs near Salt Creek, which most likely originates from Tuscan Springs, which is a source of high boron and sulfates.

SGMA prioritized the GWSBs in this area as medium priority except for the Bowman, Millville, and South Battle Creek GWSBs, which were prioritized as very low (California Department of Water Resources 2020).

Groundwater Use and Management

Tehama County uses groundwater to meet approximately 65% of its total water needs (Tehama County Flood Control and Water Conservation District 2008). Groundwater in the county provides water supply for agricultural, domestic, environmental, and industrial uses.

One of the main users of groundwater in this area is the Anderson-Cottonwood Irrigation District (ACID). Approximately 5% of the irrigated acres rely upon groundwater (California Department of Water Resources 2003). Groundwater also is the primary water supply for residences and small-scale agricultural operations.

I.1.3.3 Lower Sacramento Valley (West of Sacramento River)

The Lower Sacramento Valley area west of the Sacramento River includes three main groundwater GWSBs: Colusa, Yolo, and Solano (California Department of Water Resources 2021a).

Hydrogeology and Groundwater Conditions

Colusa Subbasin

The Colusa GWSB is bordered by the Coast Ranges to the west, Stony Creek to the north, Sacramento River to the east, and Cache Creek to the south. The Colusa GWSB extends primarily in western Glenn and Colusa counties. This GWSB is composed of continental deposits of late Tertiary age, including the Tehama and the Tuscan formations, to Quaternary age, including alluvial and floodplain deposits and Modesto and Riverbank formations. The Tehama formation represents the main water-bearing formation for the Colusa GWSB (California Department of Water Resources 2003, 2006). Groundwater levels are fairly stable in this GWSB except during droughts, such as in 1976 and 1977 and 1987 to 1992 (California Department of Water Resources 2013). Groundwater levels in the Colusa GWSB declined in the 2008 drought and increased during the wetter periods of 2010 and 2011 to the pre-drought 2008 levels (California Department of Water Resources 2014a, 2014b). Historically, groundwater levels fluctuate by approximately 5 feet seasonally during normal and dry years (California Department of Water Resources 2006, 2013). Measurements indicate that groundwater levels declined at multiple wells in the Colusa GWSB over 10 feet from fall 2018 to fall 2021, especially in the northern and southern portions of the GWSB (California Department of Water Resources 2023).

Groundwater quality for the Colusa GWSB is characterized by moderate to high TDS, with localized areas of high nitrate and manganese concentrations near the town of Colusa (California Department of Water Resources 2006, 2013). High TDS and boron concentrations have been observed near Knights Landing. High nitrate levels have been observed near Arbuckle, Knights Landing, and Willows.

The final SGMA priority designation for the Colusa GWSB is high (California Department of Water Resources 2020).

Yolo Subbasin

The Yolo GWSB lies to the south of the Colusa GWSB, primarily within Yolo County. The primary water-bearing formations for the Yolo GWSB are the same as those for the Colusa GWSB. Younger alluvium from flood basin deposits and stream channel deposits lie above the saturated zone and tend to provide substantial well yields. In general, groundwater levels are stable in this GWSB, except during periods of drought, and in certain localized pumping depressions in the vicinity of Davis, Woodland, and Dunnigan and Zamora (California Department of Water Resources 2004, 2015). However, information indicates that groundwater levels in the Yolo GWSB declined at multiple wells at least 10 feet between fall 2018 and fall 2021 (California Department of Water Resources 2023).

Groundwater quality is generally good for beneficial uses except for localized impairments, including elevated concentrations of boron in groundwater along Cache Creek and in the Cache Creek Settling Basin area, elevated levels of selenium present in the groundwater supplies for the City of Davis, and localized areas of nitrate contamination (California Department of Water Resources 2004, 2015). The Cities of Davis and Woodland, which rely heavily on groundwater supply, lost nine municipal wells since 2011 due to high nitrate concentrations (Yolo County Flood Control and Water Conservation District 2012). Sources of high nitrate concentrations near these cities have been determined to be primarily from agricultural and wastewater operations.

High salinity levels have also been reported in some areas that may be related to groundwater use for irrigation, which tends to increase salt concentrations in groundwater.

In Yolo County, as much as 4 feet of groundwater withdrawal-related subsidence has occurred since the 1950s. Groundwater withdrawal-related subsidence has damaged or reduced the integrity of highways, levees, irrigation canals, and wells in Yolo County, particularly in the vicinities of Zamora, Knights Landing, and Woodland (Water Resources Association of Yolo County 2007). Recent levels of subsidence has reached 1.5 feet (California Department of Water Resources 2023).

The Yolo GWSB final SGMA priority designation is high (California Department of Water Resources 2020).

Solano Subbasin

The Solano GWSB includes most of Solano County, southeastern Yolo County, and southwestern Sacramento County. In the Solano GWSB, general groundwater flow directions are from the northwest to the southeast (California Department of Water Resources 2004, 2015). Increasing agricultural and urban development in the 1940s in the Solano GWSB has caused substantial groundwater level declines. Groundwater levels are relatively stable but show substantial declines during drought cycles. However, information indicates that groundwater levels in the Solano GWSB declined at multiple wells at least 10 feet between fall 2020 and fall 2021 (California Department of Water Resources 2023).

Groundwater quality in the Solano GWSB is generally good and is deemed appropriate for domestic and agricultural use (California Department of Water Resources 2004, 2015). However, TDS concentrations are moderately high in the central and southern areas of the basin, with localized areas of high calcium and magnesium.

The Solano GWSB final SGMA priority designation is medium (California Department of Water Resources 2020).

Groundwater Use and Management

Many irrigators on the west side of the Sacramento Valley relied primarily on groundwater prior to completion of the CVP Tehama Colusa Canal facilities, which conveyed surface water to portions of Colusa County.

In the Colusa GWSB, although surface water is the primary source of water to meet water supply needs, groundwater is also used to assist in meeting agricultural, domestic, municipal, and industrial water needs, primarily in areas outside of established water districts. The Tehama Colusa Canal Authority service area is also an area of groundwater use in the Colusa GWSB. Although the Tehama Colusa Canal Authority delivers surface water to agricultural users when the CVP water supplies are restricted due to hydrologic conditions, water users rely upon groundwater to supplement limited surface water supplies.

Groundwater is the source of water for municipal and domestic uses in Yolo County except for the City of West Sacramento. In normal years, approximately 40% of the irrigation users in Yolo County rely on groundwater (Yolo County 2009). In the eastern portion of the Yolo GWSB, a 2006 study estimated that groundwater supplies about 80 to 85% of the total annual water demand in the county (Yolo County Flood Control and Water Conservation District 2012).

Within Yolo and Sacramento counties' portions of the Solano GWSB, groundwater is used primarily for domestic and irrigation uses. Within Solano County, groundwater is used exclusively by most rural residential landowners and the Cities of Rio Vista and Dixon (Solano County 2008). The City of Vacaville uses groundwater to provide approximately 30% of the water supply. Other communities rely upon surface water. Irrigation users within the Solano ID rely upon surface water. All other irrigation users rely upon groundwater.

I.1.3.4 Lower Sacramento Valley (East of Sacramento River)

The Lower Sacramento Valley area is east of the Sacramento River and includes seven GWSBs: Butte, Wyandotte Creek, North Yuba, South Yuba, Sutter, North American, and South American (California Department of Water Resources 2021a).

Hydrogeology and Groundwater Conditions

The aquifer system throughout the Lower Sacramento Valley east of the Sacramento River is composed of Tertiary to late Quaternary age deposits. The confined portion of the aquifer system includes the Tertiary age Tuscan and Laguna formations. The Tuscan formation consists of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash deposits. The Laguna formation consists of moderately consolidated and poorly to well cemented interbedded alluvial sand, gravel, and silt with an overall low permeability. The Quaternary portion of the aquifer system, typically unconfined, is largely composed of unconsolidated gravel, sand, silt, and clay stream channel and alluvial fan deposits. South and east of the Sutter Buttes, the deposits contain Pleistocene alluvium, which is composed of loosely compacted silts, sands, and gravels that are moderately permeable; however, nearly impermeable hardpans and claypans also exist in this deposit, which restrict the vertical movement of groundwater (California Department of Water Resources 2003, 2004, 2006).

Butte and Wyandotte Creek Subbasins

The Butte GWSB is in Butte, Colusa, Glenn, and Sutter counties. In the West Butte GWSB, groundwater levels declined during the 1976 to 1977 and 1987 to 1992 droughts, followed by a recovery in groundwater levels to pre-drought conditions of the early 1980s and 1990s (California Department of Water Resources 2004, 2015). A comparison of spring-to-spring groundwater levels from the 1950s and 1960s to levels in the early 2000s indicates about a 10-foot decline in groundwater levels in portions of this GWSB. Several groundwater depressions exist in the Chico area due to year-round groundwater extraction for municipal uses. Between spring 2012 and spring 2018, groundwater measurements indicate that groundwater levels were relatively stable, within 2.5 feet over the period, at many wells. There were a few wells with water level declines of 2.5 to 4 feet during this period (California Department of Water Resources 2023). The results were similar for the period from fall 2012 to fall 2017, with more wells showing decreases (California Department of Water Resources 2023).

The Wyandotte Creek GWSB is in Butte County. In the northern portion of the Wyandotte Creek GWSB, annual groundwater fluctuations in the confined and semiconfined aquifer system range from 15 to 30 feet during normal years (California Department of Water Resources 2004, 2015). In the southern part of Butte County, groundwater fluctuations for wells constructed in the confined and semiconfined aquifer system average 4 feet during normal years and up to 5 feet during drought years. Between fall 2018 and fall 2021, several wells showed changes of 2.5 to 10 feet. Most wells showed changes of 10 feet and above.

High nitrates occur near the Chico area in the West Butte GWSB. There are localized areas in the GWSB with high boron, calcium, electrical conductivity, and TDS concentrations (California Department of Water Resources 2004, 2015). There are several groundwater areas near Chico that historically had high perchloroethylene concentrations from industrial sites. Following implementation of groundwater treatment, the chemicals have not been detected (Butte County 2010).

There are localized high concentrations of calcium, salinity, iron, manganese, magnesium, and TDS throughout the East Butte GWSB (California Department of Water Resources 2004, 2015).

The SGMA designations for these GWSBs are medium priority (California Department of Water Resources 2020).

North and South Yuba Subbasins

The North Yuba GWSB is in Butte and Yuba counties. The South Yuba GWSB is in Yuba County. In the North Yuba and South Yuba GWSBs areas along the Feather River, the groundwater levels have been generally stable since at least 1960, with some seasonal fluctuations between spring and summer conditions. Groundwater levels in the central parts of the two GWSBs declined until about 1980 when surface water deliveries were extended to these areas and groundwater levels started to rise. Hydrographs in the central portions of the North and South Yuba GWSBs also show the effect of groundwater substitution transfers (during 1991, 1994, 2001, 2002, 2008, and 2009) in the form of reduced groundwater levels followed by recovery to pre-transfer levels (Yuba County Water Agency 2010). Between spring 2013 and spring 2018, most wells showed a stable (±2.5 feet of change) or an increased water level in the North Yuba GWSB. The South Yuba GWSB showed more wells with a decrease on the order of 3 feet combined with wells with an increased water level (California Department of Water Resources 2023).

Historical water quality data show that in most areas of the North and South Yuba GWSBs, trends of increasing concentrations of calcium, bicarbonate, chloride, alkalinity, and TDS occur. In general, groundwater salinity increases with distance from the Yuba River. No groundwater quality impairments were documented at the DWR monitoring wells in the North Yuba GWSB (California Department of Water Resources 2006). High salinity occurred in the Wheatland area of the South Yuba GWSB within the South Yuba Water District and Brophy ID (California Department of Water Resources 2006; Yuba County Water Agency 2010).

The SGMA designations for the North Yuba and South Yuba GWSBs are medium and high, respectively (California Department of Water Resources 2020).

Sutter Subbasin

The Sutter GWSB is in Sutter County. In the Sutter GWSB, groundwater levels have remained relatively constant. The water table is very shallow and most groundwater levels in the GWSB tend to be within about 10 feet of ground surface (California Department of Water Resources 2006, 2015). Information indicates that groundwater levels in the Sutter GWSB changed less than 2.5 feet between spring 2013 and spring 2018 (California Department of Water Resources 2023). At least one well had a decrease of approximately 7 feet while another had an increase of more than 9 feet. The changes from fall 2012 to fall 2017 were similar.

Groundwater quality in the western portion of the Sutter GWSB includes areas with high concentrations of arsenic, boron, calcium magnesium bicarbonate, chloride, fluoride, iron, manganese, sodium, and TDS. In the southern portion of the GWSB, groundwater in the upper aquifer system tends to be high in salinity (California Department of Water Resources 2003, 2006).

SGMA designated the Sutter GWSB as medium priority (California Department of Water Resources 2020).

North American Subbasin

The North American GWSB underlies portions of Sutter, Placer, and Sacramento counties, including several dense urban areas. Since at least the 1950s, concentrated groundwater extraction occurred east of downtown Sacramento, which resulted in a regionally extensive cone of depression. Drawdown in the wells in this area has been more than 70 feet over the past 60 years (Sacramento Groundwater Authority 2014). Water purveyors have constructed facilities to import surface water to allow groundwater levels to recover from the historical drawdown levels. In general, since around the mid-1990s to the late 2000s, water levels remained stable in the southern portion of the GWSB, and in some cases, groundwater levels are continuing to increase slightly in response to increases in conjunctive use and reductions in pumping near McClellan Air Force Base (Sacramento Groundwater Authority 2014). Groundwater levels in Sutter and northern Placer counties generally have remained stable; however, some wells in southern Sutter County have experienced declines (California Department of Water Resources 2006, 2015). Overall, groundwater levels are higher along the eastern portion of the North American GWSB and decline toward the western portion (City of Roseville et al. 2007). There is a groundwater depression in the southern Placer and Sutter counties near the border with Sacramento County. Between fall 2018 and fall 2021, many wells in the southern portion of the GWSB showed a change of less than 2.5 feet. Other wells in the GWSB showed decreases greater than 10 feet.

The area along the Sacramento River extending from Sacramento International Airport northward to the Bear River contains high levels of arsenic, bicarbonate, chloride, manganese, sodium, and TDS (California Department of Water Resources 2006, 2015). In an area between Reclamation District 1001 and the Sutter Bypass, high TDS concentrations occur. There have been three sites within the GWSB with substantial groundwater contamination issues: the former McClellan Air Force Base (North Highlands), the Union Pacific Railroad Rail Yard (Roseville), and the Aerojet Superfund Site (Rancho Cordova). Mitigation operations have been initiated for all of these sites. In the deeper portions of the aquifer, the groundwater geochemistry indicates the occurrence of connate water from the marine sediments underlying the freshwater aquifer, which mixes with the fresh water. Water quality concerns because of this type of geology include elevated levels of arsenic, bicarbonate, boron, chloride, fluoride, iron, manganese, nitrate, sodium, and TDS (California Department of Water Resources 2003).

SGMA designated the North American GWSB as high priority.

South American Subbasin

The South American GWSB is in Sacramento County. Groundwater levels in the South American GWSB have fluctuated over the past 40 years, with the lowest levels occurring during periods of drought. From 1987 to 1995, water levels declined by about 10 to 15 feet and then recovered to levels close to the mid-1980s by 2000. Over the past 60 years, a general lowering of groundwater levels was caused by intensive use of groundwater in the region. Areas affected by municipal pumping show a lower groundwater level recovery than other areas (California Department of Water Resources 2004, 2015). Between fall 2012 and fall 2017, groundwater levels varied from an increase of 40 feet to a decrease of 13 feet. Generally, the water levels increased in the western portion and decreased in the eastern portion of the GWSB (California Department of Water Resources 2023). Less data exists for the spring 2013 to spring 2018 period. The data show a range from an increase of 14 feet to a decrease of 14 feet.

The groundwater quality is characterized by low to moderate TDS concentrations (California Department of Water Resources 2004, 2015). Seven sites historically had substantial groundwater contamination, including three Superfund sites near the Sacramento metropolitan area. These sites are in various stages of cleanup.

SGMA designated the South American GWSB as high priority (California Department of Water Resources 2020).

Groundwater Use and Management

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes. Most of the groundwater extraction occurs via privately owned domestic and agricultural wells.

Butte and Wyandotte Creek Subbasins

The primary water source in Butte County is surface water (approximately 70% by volume), and groundwater use accounts for about 30% of total county water use. In Butte County, most of the irrigation users rely upon surface water, and approximately 75% of the residential water users rely upon groundwater (Butte County 2004, 2010). The Cities of Chico and Hamilton City are served by groundwater provided by California Water Service Company (California Department of Water Resources 2010).

North and South Yuba Subbasins

The Yuba County Water Agency actively manages surface water and groundwater conjunctively to prevent groundwater overdraft in the North and South Yuba GWSBs. The majority of water demand in these GWSBs is crop water use for irrigated agriculture (Yuba County Water Agency 2010).

Sutter Subbasin

Agricultural water use in Sutter County is composed, on average, of approximately 60% surface water, 20% groundwater, and 20% of land irrigated by both surface water and groundwater. Permanent crops are predominantly irrigated with groundwater. Groundwater is also used for small communities and rural domestic uses (Sutter County 2012).

North American Subbasin

Several agencies manage water resources in the North American GWSB: South Sutter Water District, Placer County Water Agency, Natomas Central Mutual Water Company, and several urban water purveyors that are part of the Sacramento Groundwater Authority, a joint powers authority (Sacramento Groundwater Authority 2014). The northern portion of this GWSB is rural and agricultural, whereas the southern portion is urbanized, including the Sacramento Metropolitan area. Many of the urban agencies in Placer County rely upon surface water for normal operations and have developed or are planning on developing groundwater for emergency situations (City of Roseville et al. 2007). In the urban area encompassed by the Sacramento Groundwater Authority, some agencies rely entirely on groundwater for their water supply (Sacramento Groundwater Authority 2014).

Local planning efforts have been implemented in a local groundwater planning area known as the American River Basin region. This area encompasses Sacramento County and the lower watershed portions of Placer and El Dorado counties and overlies the productive North American and South American GWSBs. Groundwater is a regionally substantial source of water supply and used as a primary source for many agencies in the region. However, in recent years, regional, conjunctive-use programs have allowed for the optimization of water supplies, and a decrease in groundwater use has been observed in the past five years (Regional Water Authority 2013).

Since 2000, groundwater extraction decreased in the northeastern portion of the North American GWSB as additional surface water supplies were made available under conjunctive-use operations implemented following the Water Forum Agreement in 2000. In 2007, groundwater extraction increased because additional surface water was not available due to dry surface water supply conditions (Sacramento Groundwater Authority 2013, 2014).

South American Subbasin

The South American GWSB lies entirely within Sacramento County and is overlain by a majority of urban and densely populated areas. Many of the water users in this GWSB use surface water.

The main water purveyors that use South American GWSB groundwater include the Elk Grove Water District, California American Water Company, Golden State Water Company, and the Sacramento County Water Agency. The entities serve the communities of Antelope, Arden, Lincoln Oaks, Parkway, Rosemont, and portions of the City of Rancho Cordova (California Department of Water Resources 2010). The majority of groundwater pumping is for agricultural uses (Sacramento Central Groundwater Authority 2010). The South American GWSB also includes portions of the area known as the American River Basin as described above under the *North American Subbasin* section.

I.1.4 Clear Creek

Clear Creek is a major tributary to the Sacramento River that lies just below Shasta Dam. Clear Creek originates in the mountains east of Clair Engle Reservoir and flows approximately 35 miles to its confluence with the Sacramento River, just south of the town of Redding in Shasta County. Clear Creek drains approximately 249 square miles and receives the majority of its inflow from rainfall and snowmelt.

Given that Clear Creek flows primarily through the mountain valleys, there is little in the way of substantial GWBs underlying this area. Any groundwater present in these valleys is likely in close hydraulic connection with Clear Creek. Both groundwater discharge to surface streams and leakage of stream flow to underlying aquifers are expected to occur at various locations.

I.1.5 San Joaquin Valley

Extending south into the Central Valley from the Delta to the southern extent marked by the San Joaquin River, DWR has delineated nine GWSBs within the northern portion of the San Joaquin Valley GWB based on groundwater divides, barriers, surface water features, and political boundaries (California Department of Water Resources 2003). The Cosumnes, Eastern San Joaquin, and Tracy GWSBs partially underlie the Delta. The Delta-Mendota, Modesto, Turlock, Merced, Chowchilla, and Madera GWSBs are located between the Delta and the San Joaquin River.

The northern portion of the San Joaquin Valley GWB is marked by laterally extensive deposits of thick, fine-grained materials deposited in lacustrine and marsh depositional systems. These units, which can be tens to hundreds of feet thick, create vertically differentiated aquifer systems within the GWSBs. The Corcoran Clay (or E-Clay) occurs in the Tulare formation and separates the alluvial water-bearing formations into confined and unconfined aquifers. The direction of groundwater flow generally coincides with the primary direction of surface water flows in the area, which is to the northwest toward the Delta (California Department of Water Resources 2003, 2004, 2006). Groundwater levels fluctuate seasonally, and a strong correlation exists between depressed groundwater levels and periods of drought when more groundwater is pumped in the area to support agricultural operations.

Water users in the northern portion of the San Joaquin Valley GWB rely on groundwater, which is used conjunctively with surface water for agricultural, industrial, and municipal supplies (California Department of Water Resources 2003). Groundwater is estimated to account for about 38% of the overall water supply in the northern portion of the San Joaquin Valley GWB (California Department of Water Resources 2013). Annual groundwater pumping in the northern portion of the San Joaquin Valley GWB accounts for about 19% of all groundwater pumped in the state of California. Groundwater use in the northern portion of the San Joaquin Valley GWB is estimated to average 3.2 million acre-feet per year (AFY) between 2005 and 2010.

According to the *California Water Plan Update 2013* (California Department of Water Resources 2013), three planning areas within the northern portion of the San Joaquin Valley GWB rely heavily on groundwater pumping: the Eastern Valley Floor Planning Area, the Lower Valley Eastside Planning Area, and the Valley West Side Planning Area. Each of these areas has limited local surface water supplies and uses extensive groundwater pumping for their agricultural water supply (California Department of Water Resources 2013).

The northern portion of the San Joaquin Valley GWB is divided into two subregions: West of the San Joaquin River and East of the San Joaquin River. These are described below.

I.1.5.1 West of the San Joaquin River

The Tracy and Delta-Mendota GWSBs are located on the west side of the San Joaquin River.

Hydrogeology and Groundwater Conditions

Along the western portion of the San Joaquin Valley, the Tulare formation comprises the primary freshwater aquifer. The Tulare formation originated as reworked sediments from the Coast Ranges redeposited in the San Joaquin Valley as alluvial fan, flood plain, deltaic (pertaining to a delta) or lacustrine, and marsh deposits (U.S. Geological Survey 1986).

Tracy Subbasin

The Tracy GWSB underlies eastern Contra Costa County and western San Joaquin County. A large portion of the GWSB is in the Delta. In the Tracy GWSB, groundwater generally flows from south to north and discharges into the San Joaquin River. According to DWR and the San Joaquin County Flood Control and Water Conservation District, groundwater levels in the Tracy GWSB have been relatively stable over the past 10 years, apart from seasonal variations resulting from recharge and pumping (California Department of Water Resources 2006, 2013). Measurement data indicate that between fall 2020 and fall 2021, groundwater levels declined at some wells in the Tracy GWSB by up to 15 feet (California Department of Water Resources 2023).

In the Tracy GWSB, areas of poor water quality exist throughout the area. Elevated chloride concentrations are found along the western side of the GWSB near the City of Tracy and along the San Joaquin River. Overall, Delta groundwater wells in the Tracy GWSB are characterized by high levels of chloride, TDS, arsenic, and boron (California Department of Water Resources 2006, 2015; U.S. Geological Survey 2006). The Central Valley Regional Water Quality Control Board (RWQCB) recently adopted general waste discharge requirements to protect groundwater and surface water within the San Joaquin County and Delta areas, including the Tracy GWSB (Central Valley Regional Water Quality Control Board 2014). Supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern.

The SGMA program designated the Tracy GWSB as medium priority (California Department of Water Resources 2020).

Delta-Mendota Subbasin

The Delta-Mendota GWSB underlies portions of Stanislaus, Merced, Madera, and Fresno counties. The geologic units present in the Delta-Mendota GWSB consist of the Tulare formation, terrace deposits, alluvium, and flood-basin deposits. Groundwater occurs in three water-bearing zones: the lower zone that contains confined fresh water in the lower section of the Tulare formation; the upper zone that contains confined, semiconfined, and unconfined water in the upper section of the Tulare formation; and a shallow zone that contains unconfined water (California Department of Water Resources 2006, 2015). The groundwater is characterized by moderate to extremely high salinity, with localized areas of high iron, fluoride, nitrate, and boron (California Department of Water Resources 2006, 2015).

In the Delta-Mendota GWSB, groundwater levels generally declined between 1958 and 2006 by as much as 20 feet in the northern portion of the basin near Patterson. Surface water imports in the early 1970s resulted in decreased pumping and a steady recovery of groundwater levels. However, the lack of imported surface water availability during the drought periods of 1976 to 1977, 1986 to 1992, and 2007 to 2009 resulted in increases in groundwater pumping and associated declines in groundwater levels to near-historic lows (U.S. Geological Survey 2012). Between measurements in fall 2020 and fall 2021, groundwater levels generally declined. Many wells have decreased between 4 and 40 feet (California Department of Water Resources 2023). There is one well with a reported decrease of over 200 feet. Many wells showed a decrease of at least 2.5 feet between fall 2020 and fall 2021.

In areas adjacent to the Delta-Mendota Canal in this GWSB, extensive groundwater withdrawal has caused land subsidence of up to 1.5 feet in some areas. Land subsidence can cause structural damage to the Delta-Mendota Canal, which has caused operational issues for CVP water delivery. Historical widespread soil compaction and land subsidence between 1926 and 1970 caused reduced freeboard and flow capacity of the Delta-Mendota Canal, the California Aqueduct, other canals, and roadways in the area. To better understand subsidence issues near the Delta-Mendota Canal and improve groundwater management in the area, the U.S. Geological Survey evaluated and provided information on groundwater conditions and the potential for additional land subsidence in the San Joaquin Valley. Ground surface elevation data show that a subsidence rate of up to 0.8 foot per year between 2016 and 2022 has been measured near the San Joaquin River and the Eastside Bypass. The subsidence measured was primarily inelastic (or permanent, not reversible) due to the compaction of fine-grained material. The area of maximum active subsidence is shown to be located southwest of Mendota and extends into the Merced GWSB to the south of El Nido. Land subsidence in this area is expected to continue to occur due to uncertainties and limitations (especially climate-related changes) in surface water supplies to meet irrigation demand and the continuous need to supplement water supply with groundwater pumping (U.S. Geological Survey 2013a).

Westside Subbasin

The Westside GWSB underlies portions of Kings and Fresno counties, located between the Coast Range foothills on the west and the San Joaquin River drainage and Fresno Slough on the east. The geologic units in the Westside GWSB are members of the Tulare formation. The units form a unconfined/semi-confined shallower/upper aquifer and a confined lower aquifer. The shallower and deeper units are separated by a confining aquitard unit called the Corcoran Clay (also called the E-Clay). The depth of the Corcoran clay varies between 500 and 850 feet below ground surface, with a thickness of 20 to 120 feet. Prior to groundwater development, the Corcoran Clay effectively separated the upper and lower zones. Numerous wells penetrate the clay and have allowed partial interaction between the zones. (Department of Water Resources 2006, Westlands Water District 2018)

Groundwater levels in the shallow zone have been stable since the 1990s. Several wells showed water levels rising prior to this period. Groundwater level measurements have shown decreasing elevations since the 2000s in some wells in the eastern portion of the Westside GWSB. Groundwater levels in the deeper aquifer were generally low prior to the beginning of CVP deliveries to the area in 1968. Deep groundwater levels were stable from the late 1980s through the early 2000s. Groundwater potentiometric levels in the confined deep aquifer have been declining since approximately 2010. Declines of as much as 2000 feet between 2010 and 2015 have been noted (Department of Water Resources 2006, Westlands Water District 2018).

Groundwater quality in the upper aquifer is high in calcium and magnesium sulfate. Below 300 feet and above the Corcoran Clay the total dissolved solids generally decrease with depth. Groundwater in the lower aquifer is of the sodium sulfate type and generally has a better quality than in the shallow aquifer. Groundwater in western Fresno County can have an upper range between 2,000 and 3,000 mg/L (Department of Water Resources 2006, Westlands Water District 2018).

Areas of the Westside GWSB have experienced large amounts of ground surface subsidence. Subsidence exceeded 28 feet southwest of Mendota between the mid-1920 and 1972. With the delivery of surface water from the CVP in 1968 subsidence began to slow into the 1970s. Subsidence rates began to increase again with increased reliance on groundwater supplies during the drought periods of 1976-1977, 1987-1992, 2007-2009, and 2012-2015. Subsidence is critical the water deliver infrastructure in the Westside GWSB, including the San Luis Canal. At several locations along the canal subsidence increased to over 1 foot from mile post 143 to 167 and a maximum of nearly 2 feet from mile post 129 to 133 (for the period 2000 to 2015) (Westlands Water District 2018).

Groundwater Use and Management

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes.

Tracy Subbasin

The primary water source in Contra Costa County is surface water. Groundwater is used by individual homes and businesses and the communities of Brentwood, Bethel Island, Knightsen, Byron, and Discovery Bay (Contra Costa County 2005).

The Diablo Water District groundwater-blending facility provides water to users in the City of Oakley by blending groundwater and treated water from Contra Costa Water District (California Department of Water Resources 2010).

The Contra Costa Water District has an agreement with the East Contra Costa ID to purchase surplus irrigation water for municipal and industrial purposes in East Contra Costa ID’s service area (Contra Costa Water District 2017). The agreement includes an option to implement an exchange of surface water for groundwater that can be used in the Contra Costa Water District service area when the CVP allocations are less than full contract amounts. This groundwater exchange water was implemented during the 2007 to 2009 drought.

Groundwater and surface water are used within western San Joaquin County for agricultural operations and for the Cities of Stockton, Lathrop, and Tracy (San Joaquin County 2009). In the 1980s, about 30% of the water supplies in San Joaquin County were based on groundwater (including the Tracy, Cosumnes, and Eastern San Joaquin GWSBs). By 2007, groundwater was used to supply over 60% of water demand in the county.

Delta-Mendota Subbasin

Groundwater is used for agricultural and domestic water supplies in the Delta-Mendota GWSB (Bureau of Reclamation and California Department of Water Resources 2012). Groundwater is primarily used for domestic and industrial water supplies in Stanislaus County, including for the City of Patterson (Stanislaus County 2010; City of Patterson 2014). In the Delta-Mendota GWSB within Merced County, approximately 3% of groundwater withdrawals are used for municipal and industrial purposes (including uses in the Cities of Gustine and Los Banos, and Santa Nella), and 97% of the groundwater withdrawals are used for agricultural purposes (Merced County 2012). Most of the portions of Madera County within the Delta-Mendota GWSB use groundwater for domestic and agricultural uses (Madera County 2002, 2008). In portions of western Fresno County within the Delta-Mendota GWSB, domestic water users rely upon groundwater (including the Cities of Mendota and Firebaugh), and agricultural water users rely upon surface water and/or groundwater (City of Mendota 2009; City of Firebaugh 2015; Fresno County 2000).

Canals such as the California Aqueduct and the Delta-Mendota Canal has been affected by land subsidence of up to 1.5 feet in the Delta-Mendota Subbasin (California Department of Water Resources 2020).

Westside Subbasin

Groundwater is used for agricultural and domestic water supplies in the Westside GWSB. Groundwater pumping from the upper aquifer has ranged between 3,000 and 157,400 AFY from 2011 through 2016. For the same period, pumping from the lower aquifer was estimated to be between 13,500 and 484,600 AFY (Westlands Water District 2018). In most of the Westside GWSB, the portion of groundwater pumping occurring in the lower aquifer is greater than 60 percent, with greater than 80 percent of groundwater pumping from the lower aquifer in many areas. There are areas of the subbasin (in the southeast) where the proportion of upper aquifer pumping may be relatively high (e.g., >60 percent in 2015).Canals such as the California Aqueduct and the Delta-Mendota Canal has been affected by land subsidence of up to 1.5 feet in the Westside Subbasin (California Department of Water Resources 2020).

I.1.5.2 East of the San Joaquin River

The east side of the San Joaquin River is underlain by seven groundwater GWSBs: the Cosumnes, Eastern San Joaquin, Modesto, Turlock, Merced, Chowchilla, and Madera GWSBs. The Chowchilla, Eastern San Joaquin, and Madera GWSBs are in a critical state of overdraft (California Department of Water Resources 2020).

Hydrogeology and Groundwater Conditions

Several of the hydrogeologic units present in the southern Sacramento Valley extend south into the San Joaquin Valley. Along the eastern boundary of the Central Valley, the Ione, Mehrten, Riverbank, and Modesto formations are primarily composed of sediments originating from the Sierra Nevada.

Historically, surface water and groundwater were hydraulically connected in most areas of the San Joaquin River and its tributaries. This connection resulted in a substantial quantity of groundwater actively discharging into streams in most of this watershed. However, this condition changed as increased groundwater pumping in the area lowered groundwater levels and reversed the hydraulic gradient between the surface water and groundwater systems, resulting in surface water recharging the underlying aquifer system through streambed seepage. Long-term groundwater production throughout this basin has exceeded natural recharge rates and thereby lowered groundwater levels. Areas where this overdraft has occurred include eastern San Joaquin County, Merced County, and western Madera County. Substantial surface water infiltrates from the river to the groundwater system occurs along the San Joaquin River where the riverbed is highly permeable and river water readily seeps into the underlying aquifer. As such, groundwater overdraft reduces both groundwater and surface water outflows to the Delta, lowers the water table, and may increase the potential for land subsidence (U.S. Fish and Wildlife Service 2012).

Generally, the groundwater in the San Joaquin River GWSBs east of the San Joaquin River is of suitable quality for most urban and agricultural uses with only local impairments. There are localized areas with high concentrations of boron, chloride, iron, nitrate, TDS, and organic compounds (California Department of Water Resources 2003, 2004, 2006). The use of groundwater for agricultural supply is impaired in western Stanislaus and Merced counties due to elevated boron concentrations. Groundwater use for drinking water supply is also impaired in the Tracy, Modesto-Turlock, Merced, and Madera areas due to elevated nitrate concentrations (U.S. Fish and Wildlife Service 2012).

Dibromochloropropane (DBCP), a soil fumigant that was extensively used on grapes and cotton before it was banned, is prevalent in groundwater near Merced and Stockton and in the Merced, Modesto, Turlock, Cosumnes, and Eastern San Joaquin GWSBs (Central Valley Regional Water Quality Control Board 2011; California Department of Water Resources 2004; U.S. Fish and Wildlife Service 2012). Many areas with high concentrations of DBCP have undergone groundwater remediation, and DBCP concentrations are declining.

Declining groundwater levels in the GWSBs east of the San Joaquin River have resulted in an area approximately 16 miles long with high salinity due to saltwater intrusion from the Delta (U.S. Fish and Wildlife Service 2012).

Cosumnes Subbasin

The Cosumnes GWSB underlies western Amador County, northwestern Calaveras County, southeastern Sacramento County, and northeastern San Joaquin County. Groundwater levels in the Cosumnes GWSB have fluctuated substantially over the past 40 years, with the lowest levels occurring during periods of drought. From 1987 to 1995, water levels declined by about 10 to 15 feet and then recovered by that same amount through 2000. Areas affected by municipal pumping show a lower magnitude of groundwater level recovery during this period than in other areas of the GWSB (California Department of Water Resources 2006, 2015). Between measurements in fall 2018 and fall 2021, groundwater levels declined between 2 and 8 feet (California Department of Water Resources 2023).

The Cosumnes GWSB contains groundwater of very good quality, with localized high concentrations of calcium bicarbonate and pesticides (California Department of Water Resources 2006, 2015).

The SGMA program designated the Cosumnes GWSB as medium priority (California Department of Water Resources 2020).

Eastern San Joaquin Subbasin

The Eastern San Joaquin GWSB underlies western Calaveras County, a large portion of San Joaquin County, and a portion of Stanislaus County. Groundwater levels in the Eastern San Joaquin GWSB have continuously declined in the past 40 years due to groundwater overdraft. Cones of depression are present near major pumping centers such as the City of Stockton and the City of Lodi (California Department of Water Resources 2006, 2015). Groundwater level declines of up to 100 feet have been observed in some wells. In the 1990s, groundwater levels were so low that many wells were inoperable and many groundwater users were obligated to construct new deeper wells (Northeastern San Joaquin County Groundwater Banking Authority 2004). Between spring 2014 and spring 2018, many wells, especially in the central and southern portion of the GWSB, showed water level decreases greater than 10 feet (California Department of Water Resources 2023). Groundwater level decreases were seen in wells between fall 2020 and fall 2021. Many wells showed changes in groundwater levels by 2.5 feet and below.

In the Eastern San Joaquin GWSB, the groundwater is characterized with low to high salinity levels and localized areas of high calcium or magnesium bicarbonate, salinity, nitrates, pesticides, and organic constituents (California Department of Water Resources 2006, 2015). The high groundwater salinity is attributed to poor quality groundwater intrusion from the Delta caused by the pumping-induced decline in groundwater levels, especially in the groundwater underlying the Stockton area since the 1970s (San Joaquin County Flood Control and Water Conservation District 2008). High chloride concentrations have also been observed in the Eastern San Joaquin GWSB. Ongoing studies are evaluating the sources of chloride in groundwater along a line extending from Manteca to north of Stockton. Initial concern was that long-term overdraft conditions in the eastern portion of the GWSB were enabling more saline water from the Delta to migrate inland. Other possible sources include upward movement of deeper saline formation water and agricultural practices (U.S. Geological Survey 2006). In addition, large areas of groundwater with elevated nitrate concentrations have been observed in several portions of the GWSB, such as areas southeast of Lodi and south of Stockton and east of Manteca, and in areas extending toward the San Joaquin-Stanislaus County line (U.S. Fish and Wildlife Service 2012).

The SGMA program designated the Eastern San Joaquin GWSB as high priority (California Department of Water Resources 2020).

Modesto Subbasin

The Modesto GWSB underlies northern Stanislaus County. In the Modesto GWSB, water levels declined nearly 15 feet on average between 1970 and 2000 (California Department of Water Resources 2004, 2015), with the major declines occurring in the eastern portion of the GWSB. Groundwater levels dropped by 10 feet in some areas between fall 2018 and fall 2021. Decreases in groundwater levels ranged from 2.5 to 10 feet in other areas (California Department of Water Resources 2023).

The groundwater is characterized by low to high TDS concentrations, with localized areas of boron, chlorides, DBCP, iron, manganese, and nitrate concentrations (California Department of Water Resources 2004, 2015; Stanislaus County 2010).

The SGMA program designated the Modesto GWSB as high priority (California Department of Water Resources 2020).

Turlock Subbasin

The Turlock GWSB underlies portions of Stanislaus and Merced counties. In the Turlock GWSB, water levels declined nearly 7 feet on average from 1970 through 2000 (California Department of Water Resources 2006, 2015). Comparison of groundwater contours from 1958 and 2006 shows that historically, groundwater flows occurred from east to west, toward the San Joaquin River. Groundwater pumping centers to the east of the City of Turlock have drawn the groundwater toward these cones of depression, allowing less water to flow toward the San Joaquin River and diminishing the discharge of groundwater to the river. Groundwater level data indicate that many wells showed groundwater levels decreased by at least 2.5 feet between fall 2018 and fall 2021 (California Department of Water Resources 2023). The storage capacity of the Turlock GWSB is estimated at about 15,800,000 acre-feet (AF) (California Department of Water Resources 2006, 2015).

The groundwater quality is characterized with low to high concentrations of TDS and localized high concentrations of boron, chlorides, DBCP, nitrates, and TDS (California Department of Water Resources 2015).

The SGMA program designated the Turlock GWSB as high priority (California Department of Water Resources 2020).

Merced Subbasin

The Merced GWSB underlies most of Merced County. In the Merced GWSB, water levels have declined nearly 30 feet on average from 1970 through 2000. Water level declines have been more severe in the eastern portion of the GWSB (California Department of Water Resources 2004, 2015). The estimated specific yield of the groundwater GWSB is 9%. From spring 2013 to spring 2018, several wells, especially in the northwest and southeast portions of this GWSB, showed groundwater level declines over 10 feet, approaching 50 feet (California Department of Water Resources 2023). There are also several wells with water level declines that ranged from 2.5 to 30 feet between fall 2020 and fall 2021. One well increased in groundwater by 40 feet in this period.

The groundwater quality is characterized by low to high TDS concentrations and localized areas with high concentrations of chloride, DBCP, iron, and nitrate (California Department of Water Resources 2004, 2015; U.S. Fish and Wildlife Service 2012).

The SGMA program designated the Merced GWSB as high priority (California Department of Water Resources 2020).

Chowchilla Subbasin

The Chowchilla GWSB underlies southwestern Merced County and northwestern Madera County. In the Chowchilla GWSB, water levels declined nearly 40 feet on average from 1970 to 2000. Water level declines were more severe in the eastern portion of the GWSB from 1980 to present, but the western portion of the GWSB showed the strongest declines before 1980 (California Department of Water Resources 2004, 2015). Groundwater recharge in this GWSB is primarily from irrigation water percolation. Groundwater level data show that between fall 2019 and fall 2021, groundwater levels declined by at least 2.5 feet (California Department of Water Resources 2023).

There are localized areas with high concentrations of chloride, iron, nitrate, and hardness (California Department of Water Resources 2004, 2015). Organic chemicals were detected in some wells in the Chowchilla GWSB between 1983 and 2003 (Central Valley Regional Water Quality Control Board 2011).

The SGMA program designated the Chowchilla GWSB as high priority (California Department of Water Resources 2020).

Madera Subbasin

The Madera GWSB underlies most of Madera County. In the Madera GWSB, water levels have declined nearly 40 feet on average from 1970 through 2000. Water level declines have been more severe in the eastern portion of the GWSB from 1980 to the present, but the western GWSB showed the strongest declines before this period (California Department of Water Resources 2004, 2015). At the single well with water levels collected in fall 2018 and fall 2021, a water level decline of over 60 feet was recorded (California Department of Water Resources 2023).

Groundwater in the Madera GWSB is characterized by low to high TDS and localized areas with high concentrations of chlorides, iron, nitrates, and hardness (California Department of Water Resources 2004, 2015). Occurrences of organic chemicals, including DBCP and pesticides, have been observed (Central Valley Regional Water Quality Control Board 2011; California Department of Water Resources 2004, 2015).

The SGMA program designated the Madera GWSB as high priority (California Department of Water Resources 2020).

Groundwater Use and Management

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes.

Cosumnes Subbasin

Currently, urban and agricultural water users on the valley floor are reliant on groundwater for water supply. Water demands in the Cosumnes GWSB area are supported by nearly 95% groundwater (South Area Water Council 2011). Groundwater and surface water are used for agricultural and domestic water supplies in the Cosumnes GWSB (Central Valley Regional Water Quality Control Board 2011). Groundwater is used by many agricultural water users and the community of Galt (Central Valley Regional Water Quality Control Board 2011; South Area Water Council 2011).

Central Valley RWQCB recently adopted general waste discharge requirements to protect groundwater and surface water within the San Joaquin County and Delta areas, including the Cosumnes GWSB (California Water Boards 2021). The new requirements do not address protection of groundwater related to use of recycled water on crops because those operations would require separate discharge permits from Central Valley RWQCB and are not anticipated to be widely used in this area because of limited availability of recycled water near farms. However, the supporting information recognizes the potential for groundwater impairment due to the water quality of applied water (California Water Boards 2021).

Eastern San Joaquin Subbasin

Groundwater and surface water are used for agricultural and domestic water supplies in the Eastern San Joaquin GWSB (Central Valley Regional Water Quality Control Board 2011). Groundwater is the major source of water supply for agricultural areas in eastern San Joaquin County (Northeastern San Joaquin County Groundwater Banking Authority 2007). Groundwater is used by many agricultural water users and the communities of Escalon, Lodi, Manteca, Ripon, and Stockton (Eastern San Joaquin County Groundwater Basin Authority 2004, 2007). The Cities of Manteca and Stockton use both groundwater and surface water, whereas Lodi, Escalon, and Ripon primarily use groundwater for their municipal needs.

The City of Stockton uses both surface water and groundwater for its municipal and industrial water needs. Due to overdraft of the aquifer beneath Stockton, the city has limited annual groundwater extraction. Demands on the finite groundwater resources available in the basin historically have resulted in annual groundwater withdrawals in excess of the natural recharge volume in the East San Joaquin GWSB (California Department of Water Resources 2003, 2006). This extensive use of groundwater to meet local demand results in localized overdraft conditions within the GWSB.

The Northeastern San Joaquin County Groundwater Banking Authority, now called the Eastern San Joaquin County GWB Authority, is a joint-powers authority that develops local projects to strengthen water supply reliability in Eastern San Joaquin County. The authority facilitated the development and adoption of the *Eastern San Joaquin Groundwater Basin Groundwater Management Plan* (Northeastern San Joaquin County Groundwater Banking Authority 2004) and completed an integrated regional water management plan. This plan outlines the requirements for an integrated conjunctive use program that takes into account the various surface water and groundwater facilities in eastern San Joaquin County and promotes better groundwater management to meet future basin demands (Northeastern San Joaquin County Groundwater Banking Authority 2004). Conjunctive use refers to the use and management of the groundwater resource in coordination with surface water supplies by users overlying the basin. Potential projects that could be implemented to improve groundwater conditions in the area include urban and agricultural water use efficiency projects, recycled municipal water projects, groundwater banking operations, new surface water storage opportunities, improved conveyance facilities, and utilizing new sources of surface water (Northeastern San Joaquin County Groundwater Banking Authority 2007). Pursuant to the integrated regional water management plan, a program-level environmental impact report identified potential changes to the environmental and mitigation measures to reduce identified substantial adverse effects (Northeastern San Joaquin County Groundwater Banking Authority 2011).

The Farmington Groundwater Recharge Program led by Stockton East Water District, in conjunction with the U.S. Army Corp of Engineers and other local water agencies, was developed to utilize flood-season and excess irrigation water supplies in the Eastern San Joaquin GWSB to recharge the groundwater aquifer. This program supports replenishment of a critically overdrafted GWB by recharging an average of 35,000 AF of water annually into the Eastern San Joaquin GWSB. The program includes recharge of surface water on 800 to 1,200 acres of land using direct field flooding. In addition, the program increases surface water deliveries in-lieu of groundwater pumping to reduce overdraft (Farmington Program 2012).

A joint conjunctive use and groundwater banking project was evaluated by the East San Joaquin Parties Water Authority and East Bay Municipal Utility District, named the Mokelumne Aquifer Recharge and Storage Project (Northeastern San Joaquin County Groundwater Banking Authority 2004). The goal of this project was to store surface water underground in wet years, and in dry years, the East Bay Municipal Utility District would extract and export the recovered water supply (Northeastern San Joaquin County Groundwater Banking Authority 2004, 2009). Several studies have concluded that the test area is suitable for recharge and recovery of groundwater; however, more testing needs to be done to further evaluate the feasibility of this project.

Central Valley RWQCB recently adopted general waste discharge requirements to protect groundwater and surface water within the San Joaquin County and Delta areas (California Water Boards 2021). The new requirements do not address protection of groundwater related to the use of recycled water on crops because those operations would require separate discharge permits from Central Valley RWQCB and are not anticipated to be widely used in this area because of the availability of recycled water near farms. However, the supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops (California Water Boards 2021).

Modesto Subbasin

Groundwater is used for agricultural and domestic water supplies in the Modesto GWSB (Bureau of Reclamation and California Department of Water Resources 2012). Groundwater is used by many agricultural water users and the community of Modesto (California Department of Water Resources 2004; Stanislaus County 2010).

Turlock Subbasin

Groundwater is used for agricultural and domestic water supplies in the Turlock GWSB (Bureau of Reclamation and California Department of Water Resources 2012). Groundwater is used by many agricultural water users and the community of Turlock in Stanislaus County and the communities of Delhi and Hilmar in Merced County (California Department of Water Resources 2006; Stanislaus County 2010; Merced County 2012).

Merced Subbasin

Groundwater is used for agricultural and domestic water supplies in the Merced GWSB (Bureau of Reclamation and California Department of Water Resources 2012). Groundwater is used by many agricultural water users and the communities of Atwater, El Nido, Le Grand, Livingston, Merced, Planada, and Winton (California Department of Water Resources 2004; Merced County 2012).

Chowchilla Subbasin

Groundwater is used for agricultural and domestic water supplies in the Chowchilla GWSB (Bureau of Reclamation and California Department of Water Resources 2012). Groundwater is used by many agricultural water users and the community of Chowchilla (California Department of Water Resources 2006; Madera County 2002).

Madera Subbasin

Groundwater is used for agricultural and domestic water supplies in the Madera GWSB (Bureau of Reclamation and California Department of Water Resources 2012). Groundwater is used by many agricultural water users and the community of Madera (California Department of Water Resources 2006; Madera County 2002, 2008).

I.1.6 Bay-Delta

The Delta overlies the western portion of the area where the Sacramento River and San Joaquin River GWBs converge. The Delta includes the Solano GWSB and the South American GWSB in the Sacramento Valley GWB (as described previously); the Tracy GWSB, the Eastern San Joaquin GWSB, and the Cosumnes GWSB in the San Joaquin Valley GWB (as described previously); and the Suisun-Fairfield Valley Basin (as described subsequently).

I.1.6.1 Hydrogeology and Groundwater Conditions

Each GWB in the San Francisco Bay Hydrologic Region contains unique hydrogeologic characteristics. However, generally, water-bearing materials consist of alluvial, unconsolidated sand, sand and gravel, and clay (California Department of Water Resources 2004, 2006, 2015). Aquifers in these basins are hydrologically connected to surface water bodies, such as the San Joaquin River, Suisun Bay, local streams, and San Francisco Bay.

The movement of groundwater is locally influenced by features such as faults and structural depressions and operating production wells; however, groundwater generally flows toward the nearby bays. Groundwater levels in the area exhibit seasonal variation and have been historically depressed from substantial groundwater use. However, as groundwater use decreased over the last few decades following implementation of surface water projects, groundwater levels have risen substantially. Over the entire period of record, groundwater levels have shown only a slight decline, followed by a short period of stability, and a slight decline in more recent years (California Department of Water Resources 2021b).

Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley Groundwater Basins

The Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley GWBs represent the majority of groundwater storage in northern Contra Costa County. Except for portions of the Pittsburg Plain, most of these GWBs are not located within the Delta.

These basins extend inland from Suisun Bay toward Mt. Diablo. The Pittsburg Plain GWB is composed of Pleistocene deposits of consolidated and unconsolidated clay sediments overlain by alluvial soft water-saturated muds, peat, and loose sands (California Department of Water Resources 2004, 2015). The Clayton Valley and Ygnacio Valley GWBs are composed of unconsolidated alluvium and semiconsolidated alluvium interbedded with clay, sand, and gravel lenses. Along Suisun Bay, the water-bearing formations are composed of alluvial soft water-saturated muds, peat, and loose sands (California Department of Water Resources 2004, 2015).

Groundwater levels are relatively stable because the groundwater is recharged from streams (California Department of Water Resources 2004, 2015). The streams include Kirker and Willow Creeks in the Pittsburg Plain GWB, Marsh Creek in the Clayton Valley GWB, Walnut and Grayson Creeks in the Ygnacio Valley GWB, and Alhambra Creek in the Arroyo Del Hambre Valley GWB. There are no recent data for these basins related to groundwater levels or storage capacities.

The groundwater in this area is characterized by moderate to high TDS (California Department of Water Resources 2004, 2015). High nitrate concentrations occur in some rural areas of these basins (Contra Costa County 2005).

The SGMA program designated the Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley GWBs as very low priority (California Department of Water Resources 2020).

San Ramon Valley Groundwater Basin

The San Ramon Valley GWB is in southern Contra Costa County and extends from the Alamo area southward under the Town of Danville and City of San Ramon to the county boundary.

The basin is a closed basin characterized by alluvial fan deposits of sand, gravel, silt, and clay sediments (California Department of Water Resources 2004, 2015). Multiple faults within the basin affect groundwater movement.

There are no recent data for this basin related to groundwater levels, storage capacities, or quality (California Department of Water Resources 2004, 2015).

The SGMA program designated the San Ramon Valley GWB as very low priority (California Department of Water Resources 2020).

Livermore Valley Groundwater Basin

The Livermore Valley GWB extends under northeastern Alameda County and southern Contra Costa County. The Livermore Valley GWB contains groundwater-bearing materials originating from continental deposits from alluvial fans, outwash plains, and lakes (California Department of Water Resources 2006, 2015).

The Main Basin is the aquifer that includes the highest yielding aquifers and highest quality groundwater (Zone 7 Water Agency 2018). The Main Basin generally is divided into the Upper Aquifer Zone and Lower Aquifer Zone, which are separated by a relatively continuous silty clay lens. Water from the Upper Aquifer Zone moves into the Lower Aquifer Zone when groundwater levels in the upper zone are high.

Well yields are mostly adequate and, in some areas, can produce large quantities of groundwater for all types of wells (California Department of Water Resources 2006, 2015). The movement of groundwater is locally impeded by structural features such as faults that act as barriers to groundwater flow, resulting in varying water levels in the basin. Groundwater follows a westerly flow pattern, similar to the surface water streams, along the structural central axis of the valley toward municipal pumping centers (Zone 7 Water Agency 2005).

Groundwater levels in the main portion of the Livermore Valley GWB started declining in the early 1900s when groundwater pumping removed large quantities of groundwater (Zone 7 Water Agency 2005, 2013). This trend continued until the late 1960s when Zone 7 began importing SWP water. Subsequently, Zone 7 developed surface water projects to capture local runoff. Local runoff and SWP water are stored in Lake Del Valle and used to recharge groundwater within the Livermore Valley. The importation of additional surface water alleviated the pressure on the aquifer, and groundwater levels started to rise in the 1970s. Between fall 2018 and fall 2021, groundwater levels at the majority of wells in the GWSB showed a decrease in groundwater level, some approaching 10 feet of increase and beyond (California Department of Water Resources 2023).

The Livermore Valley GWB is characterized by localized areas of high boron, nitrate, and TDS (California Department of Water Resources 2006, 2015; Zone 7 Water Agency 2018). High boron levels can be attributed to marine sediments adjacent to the basin.

Nitrate concentrations generally are within potable water criteria; however, high nitrate concentrations occur in some locations of the upper aquifer (Zone 7 Water Agency 2018). The source of nitrates appears to be related to agricultural activities, wastewater disposal, and natural sources from decaying vegetation.

Salinity of the aquifer depends upon the quality of the water used for recharge operations. Salinity has increased over the past 30 years (Zone 7 Water Agency 2018), especially in the western portion of the Main Basin. Aquifers in the central and eastern portions of the Livermore Valley GWB are generally recharged through streambeds and characterized by lower salinity due to the high recharge rate.

The SGMA program designated the Livermore Valley GWB as medium priority.

Castro Valley Groundwater Basin

The Castro Valley GWB is in the Castro Valley area of Alameda County between San Lorenzo Creek on the east and the Hayward Fault on the west (City of Castro Valley 2012).

The basin is composed of alluvial deposits of sand, gravel, silt, and clay sediments (California Department of Water Resources 2004, 2015). Previous studies indicated that the maximum yield was about 140,000 gallons per day (City of Castro Valley 2012).

The groundwater is characterized by bicarbonates with calcium and sodium. Localized contamination has occurred in this shallow aquifer related to agricultural activities and underground storage tanks (City of Castro Valley 2012).

The SGMA program designated the Castro Valley GWB as very low priority (California Department of Water Resources 2020).

Santa Clara Valley Groundwater Basin

The Santa Clara Valley GWB includes three GWSBs in areas that are within the CVP and/or SWP service areas. The three GWSBs include the East Bay Plain GWSB in Contra Costa and Alameda counties, Niles Cone GWSB in Alameda County, and Santa Clara GWSB in Santa Clara County.

East Bay Plain Subbasin

The East Bay Plain GWSB is an alluvial plain that extends from San Pablo Bay southward to the Niles Cone GWSB and extends under San Francisco Bay (California Department of Water Resources 2004, 2015; East Bay Municipal Utility District 2013). The alluvium consists of unconsolidated sediments of mud, silts, sands, and clays. Multiple faults within the GWSB affect groundwater movement. Groundwater levels declined to approximately 250 feet below the ground surface until the mid-1960s when groundwater levels began to increase. By 2000, groundwater levels were close to the ground surface. The groundwater quality is characterized as calcium and sodium bicarbonate with moderate to high TDS. Higher TDS concentrations occur near San Francisco Bay where localized seawater intrusion has occurred. High nitrate concentrations occur in localized areas due to historic agricultural activities.

SGMA designated the East Bay Plain GWSB as medium priority (California Department of Water Resources 2020).

Niles Cone Subbasin

The Niles Cone GWSB is mainly comprised of the alluvial fan along Alameda Creek. The Hayward Fault crosses the Niles Cone GWSB and further separates the GWSB into the Below Hayward Fault (west of the Hayward Fault) and Above Hayward Fault (east of the Hayward Fault) GWSBs (Alameda County Water District 2012; California Department of Water Resources 2006, 2015).

The Niles Cone GWSB was in overdraft condition through the early 1960s. After 1962, groundwater levels increased as SWP water was delivered to the area and used to recharge the groundwater GWSB (California Department of Water Resources 2006, 2015).

The main groundwater quality impairment in the Niles Cone GWSB is saltwater intrusion caused by groundwater pumping (Alameda County Water District 2012; California Department of Water Resources 2006, 2015). In the 1950s, the migration of saline water extended into the Above Hayward Fault GWSB and migrated into deeper aquifers. The Alameda County Water District (ACWD) has developed aquifer reclamation programs to help control the movement of saline water and restore the quality of groundwater in the affected aquifers as described below.

SGMA designated the Niles Cone GWSB as medium priority (California Department of Water Resources 2020).

Santa Clara Subbasin

The Santa Clara GWSB is in Santa Clara County along a structural trough that parallels the Coast Ranges and extends from the Diablo Range and Santa Cruz Mountains. Water-bearing formations of the Santa Clara GWSB include unconsolidated to semiconsolidated gravel, sand, silt and clay (California Department of Water Resources 2004, 2013). The upper alluvial fan in the northern portion of the GWSB is characterized by coarse-grained sediments (Santa Clara Valley Water District 2010). Toward the central portion of the GWSB, thick silty clay lenses are inter-bedded with thin sand and gravel lenses. The northern and central portions of the GWSB are locally referred to as the Santa Clara Plain (California Department of Water Resources 2010). The southern portion of the GWSB consists of extensive alluvial deposits of unconsolidated and semiconsolidated sediments and is referred to as the Coyote Valley (Santa Clara Valley Water District 2010). The central portions and areas along the edges of the Santa Clara Plain subbasin consist of unconfined aquifers that provide recharge to the basin (California Department of Water Resources 2010; Santa Clara Valley Water District 2010). The Shallow Aquifer consists of water-bearing sediments that are less than 150 feet deep. The Principal Aquifer provides most of the groundwater supply for the Santa Clara Valley and is separated from the Shallow Aquifer by a confining lens in some areas of the Santa Clara Plain. The groundwater recharge primarily occurs due to percolation of water on the soil from precipitation or artificial recharge operations (as described below), seepage from streambeds, and subsurface inflow from surrounding hills.

In the Coyote Valley, the groundwater aquifer is primarily unconfined with areas of perched groundwater above discontinuous clay deposits (California Department of Water Resources 2010; Santa Clara Valley Water District 2010). Groundwater recharge occurs along the streambeds. When the groundwater levels are high in the Coyote Valley, groundwater seeps into the streams.

The movement of groundwater in the Santa Clara GWSB is locally influenced by groundwater recharge activities, proximity to streams, and operating production wells (Santa Clara Valley Water District 2010). Regionally, groundwater in the Santa Clara GWSB generally flows northwest toward the San Francisco Bay.

The Santa Clara GWSB has historically experienced decreasing groundwater level trends; between 1900 and 1970, water level declines of more than 200 feet from groundwater pumping caused unrecoverable land subsidence of nearly 13 feet in San Jose (California Department of Water Resources 2010). Importation of surface water using CVP, SWP, and San Francisco Public Utilities District water supplies and the development of an artificial recharge program have resulted in rising groundwater levels and sustainable conditions since the late 1960s. The groundwater levels in some portions of this GWSB decreased by at least 10 feet between fall 2018 and fall 2021 (California Department of Water Resources 2023).

The I-32 groundwater quality in the Santa Clara GWSB is good to excellent and suitable for most beneficial uses. The groundwater meets all drinking water standards and can be used without additional treatment (Santa Clara Valley Water District 2001, 2010). Some areas affected by historical saltwater intrusion exist in the northern portion of the Santa Clara GWSB in the Shallow Aquifer. Recent groundwater monitoring has indicated that seawater intrusion appears to be stabilizing (Santa Clara Valley Water District 2012). High nitrate concentrations occur in portions of the coyote Valley.

The Santa Clara GWSB was designated as high priority in the final SGMA rankings (California Department of Water Resources 2020).

I.1.6.2 Groundwater Use and Management

Use of groundwater in the San Francisco Bay Hydrologic Region varies extensively. In the basins within Contra Costa County (Pittsburg Plain, Clayton Valley, Ygnacio Valley, Arroyo Del Hambre Valley, and San Ramon Valley), local wells are used for small agricultural activities and landscape irrigation by individual landowners. In the Livermore Valley GWB, groundwater is used for a major portion of the water supply.

Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley Groundwater Basins

Groundwater use is limited within northern Contra Costa County within the Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley GWBs. This area is in the Contra Costa Water District or East Bay Municipal Utility District service areas. These districts provide surface water to most water users in this area.

Within the Contra Costa Water District service area, groundwater use is limited. The use of existing Contra Costa Water District wells at the Mallard wellfields is limited because of the threat of contamination from adjacent industrial areas.

The City of Pittsburg operates two municipal wells from the Pittsburg Plain GWB (California Department of Water Resources 2010).

The City of Martinez operates up to two wells in the Arroyo Del Hambre Valley GWB to provide irrigation water to a municipal park (California Department of Water Resources 2010).

San Ramon Valley Groundwater Basin

Groundwater use is limited within the San Ramon Valley GWB located in southern Contra Costa County. Local wells are used for small agricultural activities and landscape irrigation by individual landowners. This area is in the East Bay Municipal Utility District service area. The district provides surface water to most water users in this area.

Livermore Valley Groundwater Basin

In the Livermore Valley GWB, Zone 7 administers oversight of the GWBs used for water supply and provides water to California Water Service Company, Dublin San Ramon Services District, City of Livermore, and City of Pleasanton. Zone 7 only withdraws groundwater that has been recharged using surface water supplies (California Department of Water Resources 2010). The California Water Service Company, Dublin San Ramon Services District, and City of Pleasanton also withdraw groundwater (California Department of Water Resources 2010).

Zone 7 manages the groundwater levels and quality in the Livermore Valley GWB to maintain groundwater levels that would avoid subsidence and provide emergency reserves for the worst credible drought (California Department of Water Resources 2006, 2015).

Zone 7 artificially recharges the Livermore Valley GWB with local surface water supplies and SWP water by releasing the surface waters into the Arroyo Mocho and Arroyo Valle (Zone 7 Water Agency 2005; California Department of Water Resources 2010). The infiltrated water is then pumped from the GWB for various uses, mostly during the summer and during drought periods when local surface water supplies are diminished and the available SWP water supplies are less than the entitlement value Zone 7, City of Livermore, City of Pleasanton, Dublin San Ramon Services District, and California Water Service Company are permitted to withdraw from this GWSB.

In 2009, Zone 7 began operation of the Mocho Groundwater Demineralization Plant (California Department of Water Resources 2010). This plant is a wellhead treatment plant that produces potable water using reverse osmosis to remove TDS and hardness from the Main Basin.

Castro Valley Groundwater Basin

Groundwater use is limited within the Castro Valley GWB. Local wells are used for small agricultural activities and landscape irrigation by individual landowners (City of Castro Valley 2012). This area is in the East Bay Municipal Utility District service area. The district provides surface water to most water users in this area.

Santa Clara Valley Groundwater Basin

The Santa Clara Valley GWB includes the East Bay Plain, Niles Cone, and Santa Clara GWSBs.

East Bay Plain Subbasin

Groundwater use is limited within the East Bay Plains GWSB. Local wells are used for small agricultural activities and landscape irrigation by individual landowners (California Department of Water Resources 2004, 2015; East Bay Municipal Utility District 2013). Well fields that served the communities were initially constructed in the late 1800s and early 1900s and were closed by 1930. This area is in the East Bay Municipal Utility District service area. The district provides surface water to most water users in this area. The East Bay Municipal Utility District initiated the Bayside Groundwater Project in 2009 to store surface water in wet years for use during droughts.

Niles Cone Subbasin

The ACWD is the primary water agency that relies upon the Niles Cone GWSB. The ACWD uses fresh groundwater from the Niles Cone GWSB and desalinated brackish groundwater in addition to local and imported surface water supplies. The Niles Cone GWSB is primarily recharged in the Alameda Creek watershed by percolation of local runoff and SWP water (Alameda County Water District 2012; California Department of Water Resources 2010). In wetter years, when local water supplies are abundant, the ACWD diverts some of the SWP allocation to the Semitropic Water Storage District in Kern County through a water banking agreement (as described for the Kern County GWSB). This agreement allows the ACWD to subsequently recover this water during drier years through an exchange agreement with Semitropic Water Storage District (Alameda County Water District 2012).

The ACWD provides retail water supplies to the Cities of Fremont, Newark, and Union City. The district has implemented treatment of brackish groundwater to allow previously unused groundwater to be used as a potable water source (Alameda County Water District 2012; California Department of Water Resources 2010). In 2003, the ACWD Newark Desalination Facility began to remove salts and other constituents from the Niles Cone GWSB groundwater that is subject to seawater intrusion using a reverse osmosis process. The aquifer reclamation program also includes withdrawing water to prevent a plume of brackish water in the Centerville-Fremont Aquifer from further migrating toward the ACWD Mowry wellfield. Future groundwater desalination facilities are being evaluated by the district.

Santa Clara Subbasin

Local water agencies and individual landowners use groundwater in the Santa Clara GWSB. The Santa Clara GWSB is primarily recharged from percolation of local runoff and water supplied by the CVP and/or SWP that is discharged to recharge facilities including streambeds and percolation ponds (Santa Clara Valley Water District 2016).

Treated water is provided by the Santa Clara Valley Water District to retail water agencies to promote conjunctive use of groundwater. The water entities in the Santa Clara GWSB that use treated surface water include the Cities of Milpitas, Mountain View, San Jose, Santa Clara, and Sunnyvale; California Water Service (Los Altos District); and San Jose Water Company Several of these entities also use surface water from San Francisco Public Utilities Commission as part of their overall water supply.

In the Santa Clara GWSB, groundwater is withdrawn by local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (California Department of Water Resources 2010). Groundwater provides approximately 40% to 50% of total water use in Santa Clara County in average water year conditions (Santa Clara Valley Water District 2017). Within the Santa Clara GWSB, the users of the most groundwater include San Jose Water Company, City of Santa Clara, Great Oaks Water Company, California Water Service, and individual landowners primarily in the southern portion of the GWSB (Santa Clara Valley Water District 2012).

The Santa Clara Valley Water District (SCVWD) is responsible for groundwater management in the Santa Clara GWSB and operates a robust and flexible conjunctive use program that uses a variety of surface water sources—local supplies, imported SWP and CVP supplies, and imported transfer options. Surface water is also supplied to some water users by the San Francisco Public Utilities Commission (Santa Clara Valley Water District 2001, 2010). The district operates an extensive system of in-stream and off-stream artificial recharge facilities to replenish the GWB and provide more flexibility to manage water supplies. Five major recharge systems allow local reservoir water and imported water to be released into in-stream recharge and percolation pond facilities for artificial recharge in the Santa Clara GWSB. Recharge in this GWSB occurs along streambeds and off-stream managed basins.

I.1.7 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. The Central Coast Region encompasses the southern planning area of the Central Coast Hydrologic Region (California Department of Water Resources 2013).

SWP water is provided to the Central Coast Region by the Central Coast Water Authority (Central Coast Water Authority 2013). The facilities divert water from the SWP California Aqueduct at Devil's Den and convey the water to the 43 million gallon per day water treatment plant at Polonto Pass. The treated water is conveyed to municipal water users in San Luis Obispo and Santa Barbara counties to reduce groundwater overdraft in these areas.

Portions of the Central Coast Region that use CVP and SWP water are included in the Central Coast Hydrologic Region, which includes 50 delineated GWBs as defined by DWR (California Department of Water Resources 2003). The basins vary from large extensive alluvial aquifers to small inland valleys and coastal terraces. Groundwater in the large alluvial aquifers exists in thick unconfined and confined basins.

Groundwater is generally used for urban and agricultural use in the Central Coast Region.

I.1.7.1 Hydrogeology and Groundwater Conditions

The areas within the CVP and SWP service areas in the Central Coast Region include the Gilroy-Hollister Valley GWB in Santa Clara County; Morro Valley and Chorro Valley GWBs in San Luis Obispo County; Santa Maria River Valley GWB in San Luis Obispo and Santa Barbara counties; and San Antonio Creek Valley, Santa Ynez River Valley, Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria GWBs in Santa Barbara County.

Gilroy-Hollister Valley Groundwater Basin

Llagas Subbasin

The Llagas GWSB is part of the larger Gilroy-Hollister Valley GWB, which extends into San Benito County to the south (Santa Clara Valley Water District 2016). Similar to the Santa Clara GWSB, the Llagas GWSB consists of unconsolidated alluvial sediments. The SCVWD is responsible for groundwater management in the Llagas GWSB and operates a robust and flexible program that uses a variety of surface water sources—local supplies, imported SWP and CVP supplies—for recharge water.

In the Llagas GWSB, groundwater is used by municipal and private well owners to meet domestic, agricultural, and industrial water needs (Santa Clara Valley Water District 2016). Groundwater provides over 95% of the total use supply in Llagas Subbasin. Almost half of the pumping in Llagas GWSB is for agricultural use. The major water users in Llagas GWSB include the cities of Morgan Hill and Gilroy, unincorporated San Martin, private well users, private water companies, and golf courses.

The Llagas GWSB generally produces groundwater of good quality that does not need treatment beyond disinfection at public water supply wells. However, the presence of elevated nitrate is an ongoing groundwater protection challenge, particularly in domestic wells (Santa Clara Valley Water District 2016). Most wells tested show stable or decreasing trends over time. The SCVWD continues to coordinate with land use and regulatory agencies to influence policies, regulations, and decisions related to nitrate management. More directly, the SCVWD's managed recharge program helps dilute nitrate, and water quality testing and nitrate treatment system rebates help reduce well owner exposure (Santa Clara Valley Water District 2018).

The Llagas GWSB was designated by SGMA as a high priority basin (California Department of Water Resources 2020).

Morro Valley and Chorro Valley Groundwater Basins

In the portions of San Luis Obispo County within the SWP service area near Morro Bay, groundwater is provided by Morro Valley and Chorro Valley GWBs. Water-bearing formations are alluvium that consists of clays, silts, sands, and gravel that extend into the Pacific Ocean (California Department of Water Resources 2004, 2015). The alluvium is recharged by seepage from streambeds and precipitation and irrigation water applied to the soils.

The I-36 groundwater has moderate TDS (California Department of Water Resources 2004, 2015). Localized areas have high nitrate concentrations California Department of Water Resources 2010). Localized areas with organic contamination are also present; however, actions have been implemented to reduce the concentrations. Seawater intrusion occurs in localized areas near the Pacific Ocean.

The SGMA program designated Morro Valley and Chorro Valley GWBs as very low priority (California Department of Water Resources 2020).

Santa Maria River Valley Groundwater Basin

The Santa Maria River Valley GWB is in San Luis Obispo and Santa Barbara counties. The water-bearing formation is primarily unconfined alluvium, with localized confined areas near the coast (California Department of Water Resources 2004, 2015; Santa Maria Valley Management Area 2012). Recharge occurs along the streambeds. Groundwater levels in the basin have fluctuated over the past 100 years, with declining groundwater levels until the mid-1970s, recovery through the mid-1980s, and declining levels through the mid-1990s. Following importation of SWP water, groundwater levels increased to historic high levels. However, in the last decade, groundwater levels have gradually declined, which could be partially due to reductions in Twitchell Reservoir releases for groundwater recharge since 2000. Groundwater levels have been maintained at levels above 15 feet above mean sea level in shallow and deep aquifers near the coast to avoid seawater intrusion. Groundwater recharge occurs along streambeds. Water released from Twitchell and Lopez Reservoirs increases groundwater recharge rates (Santa Maria Valley Management Area 2012).

Groundwater quality issues in the Santa Maria Valley GWB include hardness, nitrates, salinity, sulfate, and volatile organic compounds (California Department of Water Resources 2004, 2015; San Luis Obispo County 2011; Santa Maria Valley Management Area 2012). TDS concentrations are moderate to high. There are localized areas in the basin with high sulfate concentrations. Volatile organic compound contamination was a major issue for two wells used by the City of San Luis Obispo in the late 1980s. High nitrate concentrations occur in the shallow aquifer due to historic agricultural practices. Higher salinity levels occur in the shallow aquifer near the coast than within the inland areas or in the deep aquifer.

The SGMA program designated the Santa Maria River Valley GWB as very low priority (California Department of Water Resources 2020).

San Antonio Creek Valley Groundwater Basins

San Antonio Creek Valley GWB is located along the Pacific Ocean within San Luis Obispo and Santa Barbara counties. The water-bearing formations are characterized by unconsolidated alluvial and terrace deposits of sand, clay, silt, and gravel (California Department of Water Resources 2004, 2015). Groundwater flows toward the Pacific Ocean. A groundwater barrier to the east of the Pacific Ocean creates the Barka Slough. Groundwater has declined in some areas of the basin over the past 60 years. Groundwater quality issues include areas with high salinity near the Pacific Ocean.

The final SGMA rankings designated the San Antonio Creek Valley GWB as medium priority (California Department of Water Resources 2020).

Santa Ynez River Valley Groundwater Basins

Several GWBs in Santa Barbara County are in a state of overdraft, including the Santa Ynez River Valley GWB. The Santa Ynez GWB is located along the Pacific Ocean in southwestern Santa Barbara County. The water-bearing formations are characterized by unconsolidated alluvial and terrace deposits of gravel, sand, silt, and clay (California Department of Water Resources 2004, 2015). Groundwater flows toward the Santa Ynez River and then toward the Pacific Ocean. Groundwater recharge occurs along the streambeds.

Groundwater quality is generally good for municipal and agricultural uses. There are localized areas with high TDS near the Pacific Ocean due to seawater intrusion (California Department of Water Resources 2004, 2015).

SGMA final rankings designated the Santa Ynez River Valley GWB as medium priority (California Department of Water Resources 2020).

Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria Groundwater Basins

The Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria GWBs are located in southwestern Santa Barbara County along the Pacific Ocean and near the boundary with Ventura County. The water-bearing formations in the Goleta, Foothill, Santa Barbara, and Montecito GWBs are unconsolidated alluvium of clay, silt, sand, and/or gravel that overlays the generally confined Santa Barbara formation of marine sand, silt, and clay (California Department of Water Resources 2004, 2015).

In the Carpinteria GWB, the alluvium extends under the agricultural plain (California Department of Water Resources 2004, 2015). A confined aquifer occurs under a thick clay bed in the lower part of the alluvium. This basin includes the Santa Barbara formation; the Carpinteria formation, of unconsolidated to poorly consolidated sand with gravel and cobble; and the Casitas formation, of poorly to moderately consolidated clay, silt, sand, and gravel.

Several faults restrict groundwater flow throughout these basins. Recharge occurs along streambeds and from subsurface inflow into the basin from upland areas. Water released from Lake Cachuma increases groundwater recharge rates.

The groundwater levels in portions of these GWBs declined up to 8 feet between fall 2018 and fall 2021 and more than 40 feet in some areas (California Department of Water Resources 2023).

Groundwater quality is generally good for municipal and agricultural uses. There are localized areas with high TDS near the Pacific Ocean due to seawater intrusion (California Department of Water Resources 2004, 2015; Goleta Water District and La Cumbre Mutual Water Company 2010). High concentrations of nitrate, iron, and manganese occur in localized areas in the Goleta GWB. Localized areas of high nitrate and sulfate concentrations occur within the Foothill GWB. High concentrations of calcium, magnesium, bicarbonate, and sulfate occur in localized areas of the Santa Barbara GWB. High concentrations of iron and manganese occur in localized areas of the Montecito GWB. Localized areas with high nitrates occur within the Carpinteria GWB. Other basins are in equilibrium due to management of the basin through conjunctive use by local water districts (Santa Barbara County 2007). The Goleta GWB generally is near or above historical groundwater conditions (Goleta Water District and La Cumbre Mutual Water Company 2010), with the northern and western portions of the basin having groundwater levels near the ground surface. High groundwater levels may result in degradation to building foundations and agricultural crops (water levels within the crop root zone).

The SGMA program designated the Goleta GWB as very low priority. The final SGMA priority ranking lists the Foothill, Goleta, and Santa Barbara GWBs as very low priority. The SGMA priority for the Carpinteria and Montecito GWBs are high and medium, respectively (California Department of Water Resources 2020).

I.1.7.2 Groundwater Use and Management

Groundwater is an important source of water supply for the population of the Central Coast; it is the region’s primary water source.

Gilroy-Hollister Valley Groundwater Basin

In the Llagas GWSB, groundwater is withdrawn by local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (Santa Clara Valley Water District 2016). Groundwater provides over 95% of the total water use in Llagas Subbasin. Almost half of the pumping in Llagas GWSB is for agricultural use. The major pumpers in Llagas GWSB include Cities of Morgan Hill and Gilroy, private well users, private water companies, and golf courses.

The SCVWD is responsible for groundwater management in the Llagas GWSB and operates a flexible conjunctive use program that uses a variety of surface water sources—local supplies, imported SWP and CVP supplies, and imported transfer options. The SCVWD operates a system of in-stream and off-stream artificial recharge facilities to replenish the GWB and provide more flexibility to manage water supplies. Artificial recharge in this GWSB occurs in two major recharge systems that release water in streambeds and off-stream managed basins. Both local reservoir water and imported water are used in the Upper Llagas recharge system, while the Lower Llagas system uses only local water. The amount of water artificially recharged throughout the entire service area depends upon the availability of local, CVP, and/or SWP surface water supplies. The GWSB is in long-term balance, with sustainable conditions.

Morro Valley and Chorro Valley Groundwater Basins

The City of Morro Bay uses groundwater from Morro Valley and Chorro Valley GWBs. These basins have been designated by the California State Water Resources Control Board as riparian underflow basins. The City of Morro Bay and other users of these basins have received water rights permits, which limit the rate and volume of groundwater withdrawals (California Department of Water Resources 2010).

Santa Maria River Valley Groundwater Basin

The Santa Maria River Valley GWB is the primary water supply for irrigation in southwestern San Luis Obispo County and northwestern Santa Barbara County. Groundwater also is a major portion of the water supplies for the communities of Pismo Beach, Grover Beach, Arroyo Grande, Oceano, Nipomo, and several smaller communities in San Luis Obispo County and Guadalupe, Santa Maria, and Orcutt in Santa Barbara County (California Department of Water Resources 2010). In many cases, groundwater is the total water supply for these communities, including Nipomo Community Services District (California Department of Water Resources 2010).

The GWB was adjudicated as defined by a settlement agreement, or stipulation, in 2005 that was filed in 2008. The stipulation defined the safe yield of the basin and measures to protect groundwater supplies (California Department of Water Resources 2010). The stipulation provided for the Northern Cities Management Area, Nipomo Mesa Management Area, and Santa Maria Valley Management Area. The groundwater adjudication considers groundwater recharge from precipitation and applied irrigation water and water released from Reclamation's Twitchell Reservoir and San Luis Obispo Flood Control and Water Conservation District's Lopez Reservoir that recharge the basin from the downstream streambeds.

The Cities of Pismo Beach, Grover Beach, and Arroyo Grande; Oceano Community Services District; San Luis Obispo County; and San Luis Obispo Flood Control and Water Conservation District have formed the Northern Cities Management Area to manage and protect groundwater supplies in accordance with the adjudication stipulation (California Department of Water Resources 2010). Historical monitoring reporting indicates that the groundwater levels have varied from 20 feet above to 20 feet below mean sea level. When groundwater levels are below mean sea level, there is a potential for seawater intrusion. In 2008, groundwater levels in this area were approximately 10 feet below mean sea level. In 2010, groundwater levels had recovered and ranged from 0 to 20 feet above mean sea level. Overdraft conditions occurred more frequently prior to the groundwater adjudication and completion of the Central Coast Water

Authority project that provides SWP water supplies to the area. There is a deep aquifer under the City of Arroyo Grande (Pismo formation) that provides groundwater not addressed in the adjudicated Santa Maria GWB.

Agricultural water users and the communities of Guadalupe, Orcutt, and Santa Maria use groundwater in the Santa Maria Valley Management Area of the Santa Maria GWB (Santa Maria Valley Management Area 2012). Historically, groundwater was used to provide almost 50% of the water supply to the City of Santa Maria. Recently, groundwater supplies have become 10% to 20% of the total water supply to the city (California Department of Water Resources 2010). Groundwater provides most of the water supplies in Orcutt (California Department of Water Resources 2010).

San Antonio Creek Valley Groundwater Basin

Groundwater is used for agricultural and domestic water supplies in the San Antonio Creek Valley GWB, including the Los Alamos area (California Department of Water Resources 2004, 2015).

Santa Ynez River Valley Groundwater Basin

Groundwater is used for agricultural and domestic water supplies in the Santa Ynez River Valley GWB. Groundwater is used by all agricultural water users and the communities of Buellton, Lompoc, Solvang, Mission Hills, Vandenberg Village, and Santa Ynez (California Department of Water Resources 2004, 2015; Santa Barbara County 2007).

Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria Groundwater Basins

Groundwater is used for agricultural and domestic water supplies in the Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria GWBs within Santa Barbara County. Goleta Water District and La Cumbre Municipal Water Company are the major communities that use groundwater in the Goleta GWB (California Department of Water Resources 2004, 2010; Goleta Water District and La Cumbre Mutual Water Company 2010). This basin is operated under an adjudication settlement in 1989 and a voter-passed groundwater management plan. Historically, Goleta Water District provided up to 14% of the water supply by groundwater. The Goleta Water District has increased use of surface water from Lake Cachuma and the SWP and decreased long-term average use of groundwater to about 5% of the total water supply.

Portions of the La Cumbre Municipal Water Company and City of Santa Barbara use groundwater from the Foothill GWB. The City of Santa Barbara also relies upon groundwater from the Santa Barbara GWB. The City of Santa Barbara manages groundwater in accordance with the Pueblo water rights (California Department of Water Resources 2010).

Montecito Water District uses groundwater from the Montecito GWB. Carpinteria Valley Water District uses groundwater from the Carpinteria GWB (California Department of Water Resources 2010). Total groundwater pumping averages approximately 3,700 AFY.

I.1.8 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP. The Southern California Region GWBs are as varied as the geology that occurs in different geographic portions of the region.

- Ventura County and northwestern Los Angeles County
- Central and southern Los Angeles County and Orange County
- Western San Diego County
- Western and central Riverside County and southern San Bernardino County
- Antelope Valley and Mojave Valley

I.1.8.1 Western Ventura County and Northwestern Los Angeles County

The areas within the SWP service area in Ventura County and northwestern Los Angeles County in the Southern California Region include the Acton Valley GWB in Los Angeles County; Santa Clara River Valley, Thousand Oaks Area, and Russell Valley GWBs in Ventura and Los Angeles counties; and Simi Valley, Las Posas Valley, Pleasant Valley, Arroyo Santa Rosa Valley, Tierre Rejada, and Conejo Valley GWBs in Ventura County.

Hydrogeology and Groundwater Conditions

Acton Valley Groundwater Basin

The Acton Valley GWB is upgradient of the Santa Clara River Valley GWB and drains toward the Santa Clara River. Water-bearing formations include unconsolidated alluvium of sand, gravel, silt, and clay with cobbles and boulders and poorly consolidated terraced deposits (California Department of Water Resources 2004, 2015). Recharge occurs along the streambed, water applied to the soils, and subsurface inflow. Groundwater is characterized by calcium, magnesium, and sulfate bicarbonate, with localized areas of high concentrations of TDS, sulfate, nitrate, and chlorides.

SGMA designated the Acton Valley GWB as very low priority (California Department of Water Resources 2020).

Santa Clara River Valley Groundwater Basin

The Santa Clara Valley GWB is the source of local groundwater along the Santa Clara River watershed from the Santa Clarita Valley in northwestern Los Angeles County to the Pacific Ocean near the City of Oxnard in Ventura County. The Santa Clara River Valley GWB includes the Piru, Fillmore, Santa Paula, Mound, and Oxnard GWSBs in Ventura County and Santa Clara River Valley East Subbasin in Los Angeles County. Groundwater movement is affected by the occurrence of several fault zones (California Department of Water Resources 2004, 2006, 2015). Groundwater recharge occurs along the Santa Clara River and its tributaries and by percolation of precipitation and applied irrigation water.

The Santa Clara River Valley East GWSB is characterized by unconsolidated alluvium of sand, gravel, silt, and clay; poorly consolidated terrace deposits of gravel, sand, and silt; and the Saugus formation of poorly consolidated sandstone, siltstone, and conglomerate (California Department of Water Resources 2006, 2015).

The Piru, Fillmore, Santa Paula, Mound, and Oxnard GWSBs are characterized by alluvium of silts and clays interbedded with sand and gravel lenses. The San Pedro formation includes fine sands and gravels over the alluvium (California Department of Water Resources 2004, 2006, 2015).

Groundwater levels throughout the Santa Clara River GWB showed declines of at least 10 feet between fall 2018 and fall 2021 (California Department of Water Resources 2023).

Groundwater quality in the Santa Clara River Valley GWB is suitable for a variety of beneficial uses. However, some areas have been impaired by elevated TDS, nitrate, and boron concentrations (California Department of Water Resources 2004, 2006, 2015; Castaic Lake Water Agency et al. 2012). Groundwater quality is characterized by fluctuating salinity that increases during dry periods. Localized areas of high nitrates and organic compounds occur due to historic agricultural activities and wastewater disposal.

The SGMA program designated Piru, Oxnard, Santa Clara River Valley East, Fillmore, and Mound GWSBs as high priority whereas the Santa Paula GWSB was designated as very low priority (California Department of Water Resources 2020).

Simi Valley Groundwater Basin

The Simi Valley GWB is in Ventura County (California Department of Water Resources 2004, 2015). Water-bearing formations in this basin are characterized by generally unconfined alluvium of gravel, clays, and sands, with local clay lenses that provide confined aquifers. The Simi Fault confines the basin on the northern boundary. Groundwater recharge occurs along streambeds. Groundwater quality is characterized as calcium sulfate, with localized areas of high TDS and organic contaminants.

The Simi Valley GWB was designated by SGMA as very low priority (California Department of Water Resources 2020).

Las Posas Valley and Pleasant Valley Groundwater Basins

The Las Posas Valley and Pleasant Valley GWBs are located in western Ventura County. Groundwater is found within these basins in thick alluvium that is dominated by sand and gravel in the eastern part of the Las Posas Valley GWB and by silts and clays with lenses of sands and gravels in the western part of the Las Posas Valley GWB and the Pleasant Valley GWB (California Department of Water Resources 2006, 2015). Underlying the alluvium are the San Pedro and Santa Barbara formations of gravels, sands, silts and clays with a discontinuous aquitard located within the Santa Barbara formation. The movement of groundwater is locally influenced by features such as faults, structural depressions and constrictions, and operating production wells; however, groundwater generally flows west-southwest toward the Oxnard GWSB. Most hydrographs in the eastern part of the Las Posas Valley GWB indicate relatively unchanged groundwater levels or a slight rise since 1994. Most hydrographs in the western Las

Posas Valley and Pleasant Valley GWBs indicate that groundwater levels have risen to and been maintained at moderate levels since 1992.

Groundwater levels throughout the Las Posas Valley and Pleasant Valley GWBs showed declines of at least 10 feet between fall 2018 and fall 2021 (California Department of Water Resources 2023).

Groundwater quality in the Las Posas Valley and Pleasant Valley GWBs is suitable for a variety of beneficial uses. Moderate to high TDS concentrations occur in the Las Posas Valley GWB and the Pleasant Valley GWB (California Department of Water Resources 2006, 2015).

SGMA designated Las Posas Valley and Pleasant Valley GWBs as high priority (California Department of Water Resources 2020).

Arroyo Santa Rosa Valley Groundwater Basin

The Arroyo Santa Rosa Valley GWB is in Ventura County. The water-bearing formations include alluvium of gravel, sand, and clay and the alluvial San Pedro formation of sand and gravel (California Department of Water Resources 2006, 2015). Groundwater recharge occurs along the Santa Clara River and its tributaries and by percolation of precipitation and applied irrigation water. Fault zones affect groundwater movement within the basin. Groundwater quality is adequate for community and agricultural water uses. Localized areas of high sulfate and nitrate concentrations occur within the basin.

The SGMA program designated the Arroyo Santa Rosa Valley GWB as very low priority (California Department of Water Resources 2020).

Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area Groundwater Basins

The Tierra Rejada Valley, Conejo Valley, and Thousand Oaks GWBs in southern Ventura County are characterized by shallow alluvium that overlays marine sandstone and shale of the Modelo and Topanga formations (California Department of Water Resources 2004, 2015). In some portions of the basin, the Topanga formation of volcanic tuff, debris flow, and basaltic flow occurs. Groundwater recharge occurs along the streambeds and by percolation of precipitation and applied irrigation water. Fault zones affect groundwater movement within the basins. Groundwater quality is adequate for community and agricultural water uses. Localized areas of high alkalinity and nitrate concentrations occur within the basins. High iron and TDS occur in the Thousand Oaks Area GWB (California Department of Water Resources 2010).

The SGMA program designated the Conejo Valley, Tierra Rejada Valley, and Thousand Oaks Area GWBs as very low priority (California Department of Water Resources 2020).

Russell Valley Groundwater Basin

The Russell Valley GWB is located along the boundaries of Ventura and Los Angeles counties (California Department of Water Resources 2004, 2015). This small GWB is characterized by unconsolidated, poorly bedded, sand, gravel, silt, and clay with cobbles and boulders. The groundwater is recharged by precipitation within the basin. Groundwater quality is characterized by sodium bicarbonate and calcium bicarbonate with high sulfates and TDS in some localized areas.

SGMA designated the Russell Valley GWB as very low priority (California Department of Water Resources 2020).

Groundwater Use and Management

Groundwater is an important water supply throughout the Southern California Region. Many of the basins have been adjudicated, and groundwater management agencies have been established to manage, preserve, and regulate groundwater withdrawals and recharge actions. In Ventura County, the Fox Canyon Groundwater Management Agency was established in 1982 to implement a groundwater plan that identifies withdrawal allocations and groundwater elevation and quality criteria (Metropolitan Water District of Southern California 2007).

Acton Valley Groundwater Basin

The Acton community primarily uses groundwater supplemented by SWP water treated at the Antelope Valley East Kern Acton Water Treatment Plant (Los Angeles County Department of Public Works 2014).

Santa Clara River Valley Groundwater Basin

Communities and agricultural water users in the Santa Clara River Valley GWB use a combination of surface water and groundwater to meet water demands. Agricultural use of groundwater is greater than community use of groundwater in this basin (United Water Conservation District 2012).

Four retail water purveyors provide water service to most residents of the Santa Clara River Valley East Subbasin. These water purveyors include the Castaic Lake Water Agency; Santa Clarita Water Division, Los Angeles County Waterworks District Number 36; Newhall County Water District; and Valencia Water Company. Groundwater is used by the communities of Santa Clarita, Saugus, Canyon Country, Newhall, Val Verde, Hasley Canyon, Valencia, Castaic, and Stevenson Ranch (Castaic Lake Water Agency et al. 2012).

Water purveyors in the Piru, Fillmore, Santa Paula, Mound, and Oxnard GWSBs include the United Water Conservation District and Ventura County. The United Water Conservation District operates surface water facilities to encourage groundwater protection through conjunctive use (United Water Conservation District 2012). Groundwater issues within the United Water Conservation District service area (which includes all of the basin) include overdraft conditions, seawater intrusion, and high nitrate concentrations.

Simi Valley Groundwater Basin

The Simi Valley area primarily relies upon surface water supplies, including SWP water supplies. Groundwater is used to supplement these supplies and by users that cannot be easily served with surface water. Groundwater is provided by Golden State Water Company and Ventura County Waterworks District No. 8. The Golden State Water Company provides less than 10% of the total water supply to the area (California Department of Water Resources 2010). Ventura County Waterworks District No. 8 provides groundwater to a golf course, nursery, and industrial users in the Simi Valley area (California Department of Water Resources 2010).

Las Posas Valley and Pleasant Valley Groundwater Basins

Communities and agricultural water users in the Las Posas Valley and Pleasant Valley GWBs use a combination of surface water and groundwater to meet water demands. Agricultural use of groundwater is greater than community use of groundwater in this basin (United Water Conservation District 2012). The United Water Conservation District and Ventura County manage water service to many residents of the Las Posas Valley and Pleasant Valley GWBs.

The United Water Conservation District operates surface water facilities to encourage groundwater protection through conjunctive use (United Water Conservation District 2012). Groundwater is used within the United Water Conservation District service area, which includes western Las Posas Valley and Pleasant Valley GWBs. The Oxnard GWSB of the Santa Clara River Valley GWB and Las Posas Valley and Pleasant Valley GWBs are within the groundwater management plan established by the Fox Canyon Groundwater Management Agency (Fox Canyon Groundwater Management Agency 2013). Fox Canyon Groundwater Management Agency manages and monitors groundwater in areas with groundwater overdraft and seawater intrusion, which includes the communities of Port Hueneme, Oxnard, Camarillo, and Moorpark. The long-term average groundwater use within Fox Canyon Groundwater Management Agency includes a portion of the withdrawals reported by the United Water Conservation District.

The Calleguas Municipal Water District, in partnership with the Metropolitan Water District of Southern California, operates the Las Posas Basin Aquifer Recharge and Recovery project. The Calleguas Municipal Water District stores SWP surplus water in the Las Posas Valley GWB, near the City of Moorpark. The current aquifer recharge and recovery system includes 18 wells (California Department of Water Resources 2010).

Arroyo Santa Rosa Valley Groundwater Basin

Communities and agricultural water users in the Arroyo Santa Rosa Valley GWB use a combination of surface water and groundwater to meet water demands. Camrosa Water District and Fox Canyon Groundwater Management Agency manage groundwater supplies within the basin (Camrosa Water District 2013).

Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area Groundwater Basins

Groundwater in the Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area GWBs is primarily used by agricultural and individual residential water users. Portions of the Tierra Rejada Valley GWB is within the Camrosa Water District; however, this area is primarily open space and provides agricultural land uses with individual wells (Camrosa Water District 2013). The City of Thousand Oaks operates two wells; however, the city primarily relies upon SWP water supplies because of the high iron concentrations and salinity in the groundwater).

Russell Valley Groundwater Basin

Most groundwater users in the Russell Valley GWB are agricultural and individual residential water users. Portions of the basin are located within the Calleguas Municipal Water District. Calleguas Municipal Water District. However, the district does not use water from this basin (California Department of Water Resources 2010). The Las Virgenes Municipal Water District withdraws groundwater from the Russell Basin to augment recycled water supplies (Greater Los Angeles County Integrated Regional Water Management Region 2014).

I.1.8.2 Western Los Angeles County and Orange County

The areas within the SWP service area in Central and Southern Los Angeles County and Orange County in the Southern California Region include the San Fernando Valley, Raymond, San Gabriel Valley, Coastal Plain of Los Angeles, and Malibu Valley GWBs in Los Angeles County and Coastal Plain of Orange County and San Juan Valley GWBs in Orange County.

Hydrogeology and Groundwater Conditions

San Fernando Valley Groundwater Basin

The San Fernando Valley GWB extends under the Los Angeles River watershed. Groundwater flows toward the middle of the basin, beneath the Los Angeles River Narrows, to the Central Subbasin of the Coastal Plain of Los Angeles GWB. The water-bearing formation is mainly unconfined gravel and sand with clay lenses that provide some confinement in the western part of the basin (California Department of Water Resources 2004).

Groundwater movement is affected by the occurrence of several fault zones (California Department of Water Resources 2004). Groundwater is recharged naturally from precipitation and stream flow and from imported water and reclaimed wastewater that percolates into the groundwater from stormwater spreading grounds.

In the San Fernando Valley GWB, the groundwater is characterized by calcium, magnesium, radioactive material, and sulfate bicarbonate, with localized areas of high TDS, volatile organic compounds, petroleum compounds, chloroform, pesticides, nitrate, and sulfate (California Department of Water Resources 2004; Upper Los Angeles River Area Watermaster 2013). There are several ongoing groundwater remediation programs within the GWB to reduce volatile organic compounds and one program to reduce hexavalent chromium.

SGMA designated the San Fernando Valley GWB as very low priority (California Department of Water Resources 2020).

San Gabriel Valley Groundwater Basin

Groundwater in the San Gabriel Valley GWB flows from the San Gabriel Mountains toward the west under the San Gabriel Valley to the Whittier Narrows where it discharges into the Coastal Plain of Los Angeles GWB (California Department of Water Resources 2004). Groundwater in the San Gabriel Valley GWB also is interconnected to groundwater in the Chino GWSB of the Upper Santa Ana Valley GWB in Riverside County. The northeastern portion of the San Gabriel Valley GWB adjacent to the Chino GWSB includes six GWSBs and is known as Six Basins. Water-bearing formations include unconsolidated to semiconsolidated alluvium deposits of gravel, sands, and silts.

Groundwater recharge occurs from spreading basins and direct percolation of precipitation and stream flow, including treated wastewater effluent conveyed in the San Gabriel River (California Department of Water Resources 2004). In the San Gabriel Valley GWB, the groundwater is characterized by calcium bicarbonate, with localized areas of high TDS, carbon tetrachloride nitrate, and volatile organic compounds (California Department of Water Resources 2004).

SGMA designated the San Gabriel Valley GWB as very low priority (California Department of Water Resources 2020).

Raymond Groundwater Basin

The Raymond GWB is located to the north of the San Gabriel Valley GWB. Groundwater flow is affected by the occurrence of several fault zones and causes the groundwater to flow into the San Gabriel Valley GWB. The water-bearing formations are mainly unconsolidated gravel, sand, and silt, with local areas of confinement (California Department of Water Resources 2004). Groundwater is recharged naturally from precipitation and stream flow and from water that percolates into the groundwater from spreading grounds and local dams.

In the Raymond GWB, the groundwater is characterized by calcium, magnesium, and sulfate bicarbonate, with localized areas of high volatile organic compounds, nitrate, radioactive material, and perchlorate (California Department of Water Resources 2004). There is an ongoing groundwater remediation program within the GWB to reduce volatile organic compounds and perchlorate.

SGMA designated the Raymond GWB as very low priority (California Department of Water Resources 2020).

Coastal Plain of Los Angeles Groundwater Basin

The Coastal Plain of Los Angeles GWB includes the Hollywood, Santa Monica, Central, and West Coast GWSBs.

Hollywood Subbasin

The Hollywood GWSB is located to the north of the Central GWSB. Groundwater flows toward the Pacific Ocean (California Department of Water Resources 2004). The water-bearing formations are mainly alluvial gravel. Groundwater is recharged naturally from precipitation and stream flow.

SGMA designated the Hollywood GWSB as very low priority (California Department of Water Resources 2020).

Santa Monica Subbasin

The Santa Monica GWSB is located to the north of the West Coast GWSB and to the west of the Hollywood GWSB. Groundwater flows toward the west and the Hollywood GWSB (California Department of Water Resources 2004). The water-bearing formations are mainly alluvial gravel and sand with semiperched areas over silt and clay deposits. Unconfined shallow aquifers occur in the northern and eastern portions of the GWSB. Confined deeper aquifers occur in the remaining portion of the GWSB. Groundwater is recharged naturally from precipitation and stream flow.

SGMA program designated the Santa Monica GWSB as medium priority (California Department of Water Resources 2020).

Central Subbasin

The Central GWSB is located to the east of the West Coast GWSB. The Central GWSB is characterized by shallow sediments and extends from the Los Angeles River Narrows and Whittier Narrows, with groundwater flows from the San Gabriel Valley (California Department of Water Resources 2004).

The nonpressurized, or forebay, portions of the GWSB are located in the northern portion of the GWSB in unconfined aquifers underlying the Los Angeles and San Gabriel rivers (California Department of Water Resources 2004). These areas provide the major recharge areas for the GWSB. The pressure areas are confined aquifers composed of permeable sands and gravel separated by less permeable sandy clay and clay and constitute the main water-bearing formations. Several faults and uplifts create some restrictions to groundwater flow in the GWSB while others run parallel to the groundwater flow and do not restrict flow.

In the Central GWSB, the groundwater is characterized by localized areas of high inorganics and volatile organic compounds (California Department of Water Resources 2004).SGMA designated the Central subbasin as very low priority.

West Coast Subbasin

The West Coast GWSB is located on the southern coast of Los Angeles County to the west of the Central GWSB. The water-bearing formations are composed of unconfined and semiconfined aquifers composed of sands, silts, clays, and gravels (California Department of Water Resources 2004). Several fault zones paralleling the coast act as partial barriers to groundwater flow in certain areas. The general regional groundwater flow pattern is southward and westward toward the Pacific Ocean. Recharge occurs through groundwater flow from the Central GWSB and from infiltration along the Los Angeles and San Gabriel rivers. Seawater intrusion occurs along the Pacific Ocean coast.

In the West Coast GWSB, the most critical issue is high TDS along the Pacific Ocean coast due to seawater intrusion. Several agencies have implemented seawater barrier projects to protect the groundwater quality.

SGMA designated the West Coast GWSB as very low priority (California Department of Water Resources 2020).

Malibu Valley Groundwater Basin

The Malibu Valley GWB is an isolated alluvial basin in northern Los Angeles County along the Pacific Ocean Coast under the Malibu Creek watershed (California Department of Water Resources 2004). Groundwater flows toward the Pacific Ocean. The water-bearing formations are mainly gravel, sand, clays, and silt (California Department of Water Resources 2004). Groundwater is recharged naturally from precipitation and stream flow.

In the Malibu Valley GWB, the groundwater is characterized by localized areas of high TDS due to seawater intrusion along the Pacific Ocean coast (California Department of Water Resources 2004).

SGMA designated the Malibu Valley GWB as very low priority (California Department of Water Resources 2020).

Coastal Plain of Orange County Groundwater Basin

The Coastal Plain of Orange County GWB is under a coastal alluvial plain in northern Orange County (California Department of Water Resources 2004). Groundwater is recharged naturally from precipitation and injection wells to reduce seawater intrusion. The water-bearing formations are mainly interbedded marine and continental sand, silt, and clay deposits. The Newport-Inglewood fault zone parallels the coast and generally forms a barrier to groundwater flow. Groundwater recharge occurs along the Santa Ana River. Water levels are characterized by seasonal fluctuations (California Department of Water Resources 2015; Orange County 2009). Groundwater flowed toward the Pacific Ocean prior to recent development. However, due to extensive groundwater withdrawals, there are groundwater depressions that result in potential seawater intrusion. Groundwater levels have increased since the 1990s, following implementation of several recharge programs.

In the Coastal Plain of Orange County GWB, the groundwater is characterized as sodium-calcium bicarbonate, with localized areas of high TDS due to seawater intrusion along the Pacific Ocean coast, nitrate, and volatile organic compounds (California Department of Water Resources 2004).

SGMA designated the Coastal Plain of Orange County GWB as medium priority (California Department of Water Resources 2020).

San Juan Valley Groundwater Basin

The San Juan Valley GWB is in southern Orange County (California Department of Water Resources 2004). Groundwater flows toward the Pacific Ocean. The water-bearing formations are mainly sand, clays, and silt. Groundwater is recharged naturally from precipitation and stream flows from San Juan and Oso Creeks and Arroyo Trabuca.

In the San Juan Valley GWB, the groundwater is characterized as calcium bicarbonate, bicarbonate-sulfate, calcium-sodium sulfate, and sulfate-chloride, with localized areas of high TDS due to seawater intrusion along the Pacific Ocean coast and high fluoride near hot springs near Thermal Canyon (California Department of Water Resources 2004).

SGMA designated the San Juan Valley GWB as very low priority (California Department of Water Resources 2020).

Groundwater Use and Management

Groundwater is an important water supply throughout the Southern California Region. Many of the GWBs in Los Angeles and Orange counties have been adjudicated, and groundwater management agencies have been established to manage, preserve, and regulate groundwater withdrawals and recharge actions.

San Fernando Valley Groundwater Basin

The communities and agricultural users in the San Fernando Valley GWB use a combination of surface water and groundwater to meet water demands (Greater Los Angeles County Integrated Regional Water Management Region 2014; Upper Los Angeles River Area Watermaster 2013). The Metropolitan Water District of Southern California provides wholesale surface water supplies to several communities. The Cities of Los Angeles, Glendale, Burbank, San Fernando, Crescenta Valley, Bell Canyon, and Hidden Hills provide retail water supplies, including groundwater, to the communities. The GWB has been adjudicated and is managed by the Upper Los Angeles River Area Watermaster.

Groundwater is recharged in the San Fernando Valley GWB through seepage of precipitation within the GWB, including the recharge of stormwater at spreading grounds between 1968 and 2012, and storage of imported water (Upper Los Angeles River Area Watermaster 2013). The spreading basins for stormwater flows are operated by Los Angeles County and the Cities of Los Angeles and Burbank. A portion of the extracted groundwater is exported to areas that overlie other GWBs.

The operations of the San Fernando Valley GWB are defined by the Upper Los Angeles River Area January 26, 1979 Final Judgment; the Sylmar Basin Stipulations of August 26, 1983; and subsequent agreements. These agreements, as managed by the Upper Los Angeles River Area Watermaster, provide for the right to extract a portion of surface water, including applied recycled water, that enters specified GWSBs of the San Fernando Valley GWB, with specific calculations to identify maximum withdrawals for the Cities of Burbank, Glendale, Los Angeles, and San Fernando and Crescenta Valley Water District. The agreements also provide the right to store and withdraw water within specified GWSBs by the Cities of Burbank, Glendale, Los Angeles, and San Fernando and acknowledgment that the City of Los Angeles has an exclusive Pueblo water right for the native safe yield of the San Fernando GWSB within the larger San Fernando Valley GWB.

Raymond Groundwater Basin

The communities in the Raymond GWB use a combination of surface water and groundwater to meet water demands (Greater Los Angeles County Integrated Regional Water Management Region 2014). The Metropolitan Water District of Southern California and Foothills Municipal Water District provide wholesale surface water supplies to several communities. The Cities of Alhambra, Arcadia, Pasadena, San Marino, and Sierra Madre; Upper San Gabriel Municipal Water District; and Valley Water Company and several other private water companies provide retail water supplies, including groundwater, to the communities of Altadena, La Crescenta-Montrose, La Cañada Flintridge, Rubio Canyon, and South Pasadena. The City of Alhambra and San Gabriel Valley Municipal Water District can withdraw groundwater from the Raymond Basin but currently are not operating wells within this GWB (California Department of Water Resources 2010).

The GWB was the first adjudicated GWB in California and is managed by the Raymond Basin Management Board as the watermaster (Raymond Basin Management Board 2014). The Raymond Basin Management Board limits the amount of groundwater withdrawals in different areas of the basin and allows for short- and long-term storage of water in the GWB.

Groundwater is recharged in the Raymond GWB through seepage of precipitation within the GWB, injection wells, and spreading basins operated by Los Angeles County and the Cities of Pasadena and Sierra Madre (Metropolitan Water District of Southern California 2007). Water from the Metropolitan Water District of Southern California, which is generally a combination of SWP water and Colorado River water, cannot be used for direct recharge if the TDS is greater than 450 milligrams/liter (Raymond Basin Management Board 2014). A portion of the extracted groundwater is exported to areas that overlie other GWBs.

San Gabriel Valley Groundwater Basin

The communities in the San Gabriel Valley GWB use a combination of surface water and groundwater to meet water demands (Greater Los Angeles County Integrated Regional Water Management Region 2014; Metropolitan Water District of Southern California 2007). The Metropolitan Water District of Southern California, San Gabriel Valley Municipal Water District, Upper San Gabriel Municipal Water District; Three Valleys Municipal Water District, and Covina Irrigating Company provide wholesale surface water and/or groundwater supplies to several communities. The Cities of Alhambra, Arcadia, Azusa, Covina, El Monte, Glendora, La Verne, Monrovia, Pomona, San Marino, and Upland; San Gabriel Valley Municipal Water District and Valley County Water District; and private water companies such as Golden State Water Company, San Antonio Water Company, San Gabriel Valley Water Company, Suburban Water Systems, Valencia Heights Water Company, and others provide retail water supplies, including groundwater, to users within their communities. Additionally, they provide retail water supplies, including groundwater, to the communities of Baldwin Park, Bradbury, Claremont, Duarte, Hacienda Heights, Irwindale, La Puente, Montebello, Monterey Park, Pico Rivera, Rosemead, San Dimas, San Gabriel, Santa Fe Springs, Sierra Madre, South El Monte, South San Gabriel, Temple City, Valinda, and Whittier (California Department of Water Resources 2010; City of Alhambra 2011; City of Arcadia 2011; City of La Verne 2011; City of Pomona 2011; City of Upland 2011; Golden State Water Company 2011d; San Gabriel County Water District 2011; San Gabriel Valley Water Company 2011; Suburban Water Systems 2011; San Antonio Water Company 2011; Three Valleys Municipal Water District 2011; Upper San Gabriel Valley Municipal Water District 2013).

The San Gabriel Valley GWB includes several adjudicated basins. A portion of the GWB is managed by the San Gabriel River Watermaster and the Main San Gabriel Basin Watermaster (Metropolitan Water District of Southern California 2007; California Department of Water Resources 2010; San Gabriel Valley Water Company 2011). The Watermasters coordinate groundwater elevation and water quality monitoring, coordinate imported water supplies, coordinate recharge operations with imported water and recycled water, manage the amount of groundwater withdrawals in different areas of the basin by balancing the amount of groundwater recharge, and allow for short- and long-term storage of water in the GWB. Groundwater is recharged through seepage of precipitation within the GWB, injection wells, and spreading basins operated by Los Angeles County and a private water company (Metropolitan Water District of Southern California 2007). Water recharged into the spreading basins is from the Metropolitan Water District of Southern California and San Gabriel Valley Municipal Water District.

The Six Basins portion of the GWB also is adjudicated and managed by the Six Basins Watermaster Board (Metropolitan Water District of Southern California 2007). The Watermaster manages withdrawals and requires replenishment obligation of equal amounts for withdrawals over the operating safe yield of the basin. The Pomona Valley Protective Agency conveys flows from San Antonio Creek and SWP water to the San Antonio Spreading Grounds and from local waters to the Thompson Creek Spreading Grounds. The City of Pomona conveys flows from local surface waters to the Pomona Spreading Grounds. Los Angeles County Department of Public Works conveys flows from local surface water and SWP water to the Live Oak Spreading Grounds.

The Cities of Alhambra, Arcadia, La Verne, Monterey Park, San Gabriel Valley Water Company, and other water entities operate groundwater treatment facilities to remove dichloroethane, chloroform, other volatile organic compounds, and/or nitrates (California Department of Water Resources 2010; City of Alhambra 2011; City of Arcadia 2011; City of Monterey Park 2012; Metropolitan Water District of Southern California 2007; San Gabriel Valley Water Company 2011).

Coastal Plain of Los Angeles Groundwater Basin

The Coastal Plain of Los Angeles GWB includes four GWSBs: Hollywood, Santa Monica, Central, and West Coast.

Hollywood Subbasin

The primary user of groundwater in the Hollywood GWSB is the City of Beverly Hills (Metropolitan Water District of Southern California 2007). The basin is not adjudicated. The city manages the GWSB through limits on withdrawals and discharges to the groundwater. Groundwater is recharged through seepage of precipitation within the GWSB (California Department of Water Resources 2010; City of Beverly Hills 2011). All groundwater withdrawn by the city is treated to reduce salinity.

Santa Monica Subbasin

The primary user of groundwater in the Santa Monica GWSB is the City of Santa Monica (Metropolitan Water District of Southern California 2007). The basin is not adjudicated. Groundwater is recharged through seepage of precipitation within the GWSB (California Department of Water Resources 2010; City of Santa Monica 2011; Metropolitan Water District Southern California 2007). Groundwater treatment is provided to a portion of the GWSB withdrawals to reduce volatile organic compounds and methyl tertiary butyl ether.

Central Subbasin

The communities in the Central GWSB use a combination of surface water and groundwater to meet water demands (Greater Los Angeles County Integrated Regional Water Management Region 2014; Metropolitan Water District of Southern California 2007). The Metropolitan Water District of Southern California and Central Basin Municipal Water District provide wholesale surface water supplies to several communities. The Cities of Bell, Bell Gardens, Cerritos, Compton, Cudahy, Downey, Huntington Park, Lakewood, Long Beach, Los Angeles, Lynwood, Monterey Park, Norwalk, Paramount, Pico Rivera, Santa Fe Springs, Signal Hill, South Gate, Vernon, and Whittier; Los Angeles County Water District, La Habra Heights County Water

District, Orchard Dale Water District, and Paramount Water District; and private water companies such as Golden State Water Company, Suburban Water Systems, Bellflower-Somerset Mutual Water Company, Montebello Land and Water Company, Park Water Company, Dominguez Water Corp, California Water Service Company, San Gabriel Valley Water Company, Walnut Park Mutual Water Company, and others provide retail water supplies, including groundwater, to users within their communities. Additionally, they provide retail water supplies, including groundwater, to the communities of Artesia, Commerce, Dominguez, East La Mirada, East Los Angeles, East Rancho, Florence-Graham, Hawaiian Gardens, La Mirada, Los Nieto, Maywood, Montebello, South Whittier, Walnut Park, Westmount, West Whittier, and Willow Brook (Central Basin Municipal Water District 2011; California Department of Water Resources 2010; City of Monterey Park 2012; City of Norwalk 2011; City of Paramount 2011; City of Pico Rivera 2011; City of Santa Fe Springs 2011; City of South Gate 2011; City of Vernon 2011; City of Whittier 2011; La Habra Heights County Water District 2012; Golden State Water Company 2011e, 2011f, 2011g, 2011h; Suburban Water Systems 2011).

The Central GWSB was adjudicated and is managed by DWR. The adjudication specifies a total amount of allowed annual withdrawals (or Allowable Pumping Allocation) in the Central GWSB (Metropolitan Water District of Southern California 2007; Water Replenishment District of Southern California 2013a). Approximately 25% of the water users of groundwater from the Central GWSB are not located on the land that overlies the GWSB (California Department of Water Resources 2010; Central Basin Municipal Water District 2011). Groundwater from the San Gabriel Valley GWB also is used by water users that overlie the Central GWSB.

The Water Replenishment District of Southern California has the statutory authority to replenish the groundwater in the Central and West Coast GWSBs of the Coastal Plain of Los Angeles GWB. The Water Replenishment District of Southern California purchases water for water replenishment facilities operated by Los Angeles County Department of Public Works at the Montebello Forebay near the Rio Hondo and San Gabriel rivers near the boundaries of the Central and West Coast GWSBs (California Department of Water Resources 2010; Central Basin Municipal Water District 2011; Los Angeles County Department of Public Works 2015; Water Replenishment District of Southern California 2013a). The Montebello Forebay includes the Rio Hondo Coastal Basin Spreading Grounds along the Rio Hondo Channel, the San Gabriel River Coastal Basin Spreading Grounds, and the unlined reach of the lower San Gabriel River from Whittier Narrows Dam to Florence Avenue (Water Replenishment District of Southern California 2013a).

The replenishment water is purchased water from two sources: recycled water from various regional treatment facilities and imported water (Water Replenishment District of Southern California 2013a). The recycled water is used for groundwater recharge at the spreading grounds and at the seawater barrier wells. The Water Replenishment District of Southern California must blend recycled water with other water sources to meet the groundwater recharge water quality and volumetric requirements established by the California State Water Resources Control Board. This blended water is either imported water from the SWP and/or the Colorado River or untreated surface water flows from the San Gabriel River, Rio Hondo River, and waterways in the San Gabriel Valley (California Department of Water Resources 2010; Central Basin Municipal Water District 2011). Up to 35% of the replenishment water can be provided from recycled water supplies. Several recent projects have been implemented to store stormwater flows for increased replenishment water volumes.

In the Central GWSB, the Water Replenishment District of Southern California also purchases imported and recycled water for injection by the Los Angeles County Department of Public Works into the portion of the Alamitos Barrier Project located in Los Angeles County to reduce seawater intrusion (Metropolitan Water District of Southern California 2007; Water Replenishment District of Southern California 2007). Initially, imported SWP water was used to prevent seawater intrusion. However, over the past 20 years, recycled water has been used for a substantial amount of the groundwater injection program. The Water Replenishment District of Southern California is planning to fully use recycled water at the Alamitos Gap Barrier Project by 2014 (Water Replenishment District of Southern California 2013b).

The Cities of Long Beach, Monterey Park, South Gate, and Whittier operate groundwater treatment facilities in the Central GWSB (City of Long Beach 2012; City of Monterey Park 2012; California Department of Water Resources 2010; City of South Gate 2011; City of Whittier 2011).

West Coast Subbasin

The communities in the West Coast GWSB use a combination of surface water and groundwater to meet water demands (Greater Los Angeles County Integrated Regional Water Management Region 2014; Metropolitan Water District of Southern California 2007). The Metropolitan Water District of Southern California and West Basin Municipal Water District provide wholesale surface water supplies to several communities. The Cities of Inglewood, Lomita, Manhattan Beach, and Torrance and private water companies such as Golden State Water Company, California Water Service Company, and others provide retail water supplies, including groundwater, to users within their communities and to the communities of Athens, Carson, Compton, Del Aire, Gardena, Hawthorne, Hermosa Beach, Inglewood, Lawndale, Lennox, Redondo Beach, and Torrance (West Basin Municipal Water District 2011; City of Inglewood 2011; City of Lomita 2011; City of Manhattan Beach 2011; City of Torrance 2011; Golden State Water Company 2011i; California Department of Water Resources 2010; California Water Service Company 2011c, 2011d, 2011e, 2011f). The communities of El Segundo, Long Beach, and Los Angeles overlie the West Coast GWSB; however, no groundwater from this GWSB is used in these communities due to water quality issues and facilities locations. Groundwater use is primarily for emergency uses, including firefighting, in the communities of Hawthorne, Lomita, and Torrance because of high concentrations of minerals (e.g., iron and manganese), sulfides, and/or volatile organic compounds.

The West Coast GWSB was adjudicated and is managed by DWR. The adjudication specifies a total amount of allowed annual withdrawals (or Allowable Pumping Allocation) in the West Coast GWSB (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007; Water Replenishment District of Southern California 2013a). Groundwater from the Central GWSB is used by some water users that overlie the West Coast GWSB.

The Water Replenishment District of Southern California has the statutory authority to replenish the groundwater in the Central and West Coast GWSBs of the Coastal Plain of Los Angeles GWB. In the West Coast GWSB, the Water Replenishment District of Southern California purchases imported and recycled water for injection by the Los Angeles County Department of Public Works into the West Coast Barrier Project and the Dominguez Barrier Project (Metropolitan Water District of Southern California 2007; Water Replenishment District of Southern California 2007; Water Replenishment District of Southern California 2013b). Water is purchased the Water Replenishment District of Southern California for injection at the barrier projects (Water Replenishment District of Southern California 2013b). Initially, imported SWP water was used to prevent seawater intrusion. However, over the past 20 years, recycled water has been used for a substantial amount of the groundwater injection program. The Water Replenishment District of Southern California is planning to fully use recycled water at the West Coast Barrier Project and the Dominguez Barrier Project by 2014 and 2017, respectively (Water Replenishment District of Southern California 2013b).

California Water Service Company operates groundwater treatment facilities within the community of Hawthorne (California Department of Water Resources 2010; California Water Service Company 2011c). The Water Replenishment District of Southern California operates the Robert W. Goldsworthy Desalter near Torrance to reduce salinity for up to 18,000 AFY of groundwater located inland of the West Coast Basin Barrier (Water Replenishment District of Southern California 2013a).

The West Basin Municipal Water District treats brackish groundwater at the C. Marvin Brewer Desalter Facility for two wells near Torrance that are affected by a saltwater plume in the West Coast GWSB (California Department of Water Resources 2010).

Malibu Valley Groundwater Basin

No groundwater is used by the communities in this GWB, including the Malibu area (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007).

Coastal Plain of Orange County Groundwater Basin

The communities in the Coastal Plain of Orange County GWB use a combination of surface water and groundwater to meet water demands (Metropolitan Water District of Southern California 2007). The Municipal Water District of Orange County, Orange County Water District, and East Orange County Water District provide wholesale surface water supplies to several communities. The Cities of Anaheim, Buena Park, Fountain Valley, Fullerton, Garden Grove, Huntington Beach, La Habra, La Palma, Newport Beach, Orange, Santa Ana, Seal Beach, Tustin, and Westminster; East Orange County Water District, Irvine Ranch Water District, Mesa Consolidated Water District, Rowland Water District, Serrano Water District, Walnut Valley Water District, and Yorba Linda Water District; and private water companies such as Golden State Water Company, California Water Service Company, California Domestic Water Company, and others provide retail water supplies, including groundwater, to users within their communities and to the communities of Brea, Costa Mesa, Cypress, Diamond Bar, Garden Grove, Hacienda Heights, Industry, Irvine, La Palma, La Puente, Los Alamitos, Midway City, Newport Beach, Orange, Panorama Heights, Placentia, Pomona, Rowland Heights, Rossmoor, Seal Beach, Stanton, Villa Park, Walnut, West Covina, West Orange, and Yorba Linda (California

Department of Water Resources 2010). Groundwater use is primarily for nonpotable water uses in West Covina and for supplemental supplies for users of recycled water in Rowland Heights.

The Coastal Plain of Orange County GWB is managed by the Orange County Water District in accordance with special State legislation to increase supply and provide uniform costs for groundwater (Metropolitan Water District of Southern California 2007). The basin is managed to maintain a water balance over several years using two-step pricing levels to incentivize users to obtain alternative water supplies after withdrawing a basin production target. The GWB is managed to provide approximately a 3-year drought supply.

The Orange County Water District manages an extensive groundwater recharge program in the Coastal Plain of Orange County Basin (Orange County Water District 2014). The Orange County Water District manages spreading basins along the Santa Ana River and Santiago Creek for groundwater recharge (Metropolitan Water District of Southern California 2007). Water is supplied to these basins with flows diverted from the Santa Ana River into the recharge basins at inflatable rubber dams, SWP water, and recycled water from the Orange County Water District /Orange County Sanitation District Groundwater Replenishment System Advanced Water Purification Facility (Orange County Water District Water District n.d.).

The Orange County Water District also injects water into the Talbert Barrier and the portion of the Alamitos Barrier Project within Orange County. Water supplies for the seawater barriers include water from the Groundwater Replenishment System and SWP water (Orange County Water District n.d.; Metropolitan Water District of Southern California 2007).

The Irvine Desalter Project was initiated in 2007 by the Orange County Water District, Irvine Ranch Water District, Metropolitan Water District of Orange County, Metropolitan Water District of Southern California, and the U.S. Navy to reduce TDS and salts (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007). Several other treatment facilities remove volatile organic compounds. The city of Tustin operates the Tustin Seventeenth Street Desalter to reduce TDS within the Tustin community (Metropolitan Water District of Southern California 2007). The City of Garden Grove and Mesa County Water District operate treatment facilities to reduce nitrates and compounds that change the color of the water, respectively (California Department of Water Resources 2010).

San Juan Valley Groundwater Basin

The communities in the San Juan GWB use a combination of surface water and groundwater to meet water demands (Metropolitan Water District of Southern California 2007). The Municipal Water District of Orange County provides wholesale surface water supplies to several communities. The City of San Juan Capistrano; Moulton Niguel Water District, Santa Margarita Water District, and South Coast Water District provide retail water supplies to users within their communities and to the communities of Coto de Caza, Dana Point, Laguna Forest, Laguna Woods, Las Flores, Ladera Ranch, Mission Viejo, Rancho Santa Margarita, South Laguna, Talega, (California Department of Water Resources 2010). Most of the groundwater use occurs within or near the City of San Juan Capistrano. Groundwater use is small or does not occur within the Santa Margarita Water District, South Coast Water District, and Moulton Niguel Water District service areas.

The San Juan Basin Authority manages water resources development in the San Juan Valley GWB and in the surrounding San Juan watershed to protect water quality and water resources (Metropolitan Water District of Southern California 2007; San Juan Basin Authority 2013). In addition to community uses, groundwater is used for agricultural and industrial purposes and golf course irrigation. Overall, groundwater provides less than 10% of the total water supply within the GWB.

The City of San Juan Capistrano Groundwater Recovery Plant reduces iron, manganese, and TDS concentrations. This city is modifying the treatment plant to reduce recently observed high concentrations of methyl tertiary butyl ether (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007). The South Coast Water District operates the Capistrano Beach Groundwater Recovery Facility in Dana Point to reduce iron and manganese concentrations (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007).

I.1.8.3 Western San Diego County

The areas within the SWP service area in western San Diego County in the Southern California Region include the San Mateo Valley GWB in Orange and San Diego counties and the San Onofre Valley, Santa Margarita Valley, San Luis Rey Valley, Escondido Valley, San Marcos Area, Batiquitos Lagoon Valley, San Elijo Valley, San Dieguito Creek, Poway Valley, San Diego River Valley, El Cajon Valley, Mission Valley, Sweetwater Valley, Otay Valley, Tijuana Basin GWBs in San Diego County.

Hydrogeology and Groundwater Conditions

In San Diego County, several smaller GWBs exist, in the western portion of the county. The most productive GWBs are characterized by narrow river valleys filled with shallow sand and gravel deposits. Groundwater occurs farther inland in fractured bedrock and semiconsolidated sedimentary deposits with limited yield and storage (San Diego County Water Authority et al. 2013).

San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins

The San Mateo Valley GWB is in southern Orange County and northern San Diego County The San Onofre Valley and Santa Margarita Valley GWBs are located in northwestern San Diego County (California Department of Water Resources 2004). Groundwater flows toward the Pacific Ocean. The water-bearing formations are mainly gravel, sand, clays, and silt. Groundwater is recharged naturally from precipitation and stream flows. In the San Mateo Valley and San Onofre Valley GWBs, treated wastewater effluent discharged from the Marine Corps Base Camp Pendleton wastewater treatment plants into local streams also recharges the groundwater. In the San Mateo Valley and Santa Margarita Valley GWBs, the groundwater is characterized as calcium-sulfate-chloride. In the San Onofre Valley GWB, the groundwater is characterized as calcium-sodium bicarbonate-sulfate. Localized areas with high boron, chloride, magnesium, nitrate, sulfate, and TDS occur in the Santa Margarita Valley GWB.

SGMA designated the Santa Margarita Valley GWB as medium priority. San Mateo Valley and San Onofre Valley GWBs were designated as very low priority (California Department of Water Resources 2020).

San Luis Rey Valley Groundwater Basin

The San Luis Rey Valley GWB is in northwestern San Diego County and is subdivided into two GWSBs: the Upper San Luis Rey Valley Groundwater Subbasin and the Lower San Luis Rey Valley Groundwater Subbasin (California Department of Water Resources 2004, 2023). Groundwater flows toward the Pacific Ocean. The water-bearing formations are mainly gravel and sand. Under some portions of the alluvial aquifer, partially consolidated marine terrace deposits of partly consolidated sandstone, mudstone, siltstone, and shale occur. Groundwater is recharged naturally from precipitation and stream flows and from runoff that flows into the streams from lands irrigated with SWP water. The groundwater is characterized as calcium-sodium bicarbonate-sulfate, with localized areas of high magnesium, nitrate, and TDS (Metropolitan Water District of Southern California 2007).

The SGMA priority for the Upper San Luis Rey Valley Subbasin is medium, and the SGMA priority for the Lower San Luis Rey Valley Subbasin is very low (California Department of Water Resources 2020).

San Marcos Valley, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley Groundwater Basins

The San Marcos Valley, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley GWBs are located in the foothills within central, western San Diego County. The water-bearing formations are mainly alluvium of sand, gravel, clay, and silt; consolidated sandstone; or weathered crystalline basement rock (California Department of Water Resources 2004). The basins area is bounded by semipermeable marine and nonmarine deposits and impermeable granitic and metamorphic rocks. Groundwater is recharged naturally from precipitation and stream flows and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high concentrations of salinity. There are localized areas with high sulfate and nitrate concentrations in the Santa Maria Valley GWB.

SGMA designated the San Pasqual Valley GWB as medium priority. San Marcos Valley, Escondido Valley, Pamo Valley, Santa Maria, and Poway Valley GWBs were designated as very low priority (California Department of Water Resources 2020).

Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley Groundwater Basins

The Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley GWBs are located along the central San Diego County coast of the Pacific Ocean. The water-bearing formations are mainly alluvium of sand, gravel, clay, and silt with areas of consolidated sandstone (California Department of Water Resources 2004). Some areas of the Batiquitos Lagoon Valley GWB are bounded by impermeable crystalline rock. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high concentrations of salinity.

SGMA designated Batiquitos Valley, San Elijo Valley, and San Dieguito Valley GWBs as very low priority (California Department of Water Resources 2020).

San Diego River Valley, El Cajon, Mission Valley Groundwater Basins

The San Diego River Valley, El Cajon, and Mission Valley GWBs are located in the southwestern portion of San Diego County. The water-bearing formations are mainly alluvium of sand, gravel, cobble, clay, and silt or siltstone and sandstone (California Department of Water Resources 2004). Groundwater is recharged naturally from precipitation and stream flows and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high levels of salinity. A recent U.S. Geological Survey study evaluated the sources and movement of saline groundwater in these GWBs (U.S. Geological Survey 2013b). The chloride concentrations ranged from 57 to 39,400 milligrams per liter. The sources of salinity were natural geologic sources and seawater intrusion. There are localized areas with high sulfate and magnesium concentrations.

SGMA designated the San Diego River Valley El Cajon, and Mission Valley GWBs as very low priority (California Department of Water Resources 2020).

Groundwater Use and Management

Groundwater production and use in the San Diego region is currently limited due to a lack of aquifer storage capacity, available recharge, and degraded water quality because of high salinity. Groundwater currently represents about 3% of the water supply portfolio within the areas of San Diego County that could be served by SWP water (San Diego County Water Authority et al. 2013).

San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins

The primary user of groundwater in the San Mateo Valley, San Onofre Valley, and Santa Margarita Valley GWBs is the Marine Corps Base Camp Pendleton (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007; San Diego County Water Authority et al. 2013). The Marine Corps Base Camp Pendleton withdraws approximately 8,500 AFY from the three GWBs and operates spreading basins to recharge the groundwater in the Santa Margarita Valley GWB. Portions of the South Coast Water District overlie the northern portions of the San Mateo Valley GWB; however, the district does not withdraw water from that basin. Fallbrook Public Utility District overlies northern portions of the Santa Margarita Valley GWB; however, the district currently uses a small amount of groundwater to meet their water demand (California Department of Water Resources 2010).

The Santa Margarita Valley GWB is within an adjudicated watershed (Santa Margarita River Watershed Watermaster 2011). The Santa Margarita River Watermaster manages both surface water and groundwater that contributes direct or indirect flows into the Santa Margarita River in accordance with the Modified Final Judgment and Decrees of 1966 by the U.S. District Court in the *United States v. Fallbrook Public Utility et al.* The watershed includes the Santa Margarita Valley GWB near the Pacific Ocean and the Temecula Valley GWBs in the upper Santa Margarita River Watershed within Riverside County as discussed in the following subsection. Within San Diego County, the only groundwater user in the Santa Margarita Valley GWB is the Marine Corps Base Camp Pendleton.

San Luis Rey Valley Groundwater Basin

The communities in the San Luis Rey Valley GWB use a combination of surface water and groundwater to meet water demands (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007; Yuima Municipal Water District 2014a, 2014b). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The City of Oceanside; Rainbow Municipal Water District, Valley Center Municipal Water District, and Yuima Municipal Water District; and Rancho Pauma Mutual Water Company and other private water companies provide retail water supplies to users within their communities. Groundwater use is small or does not occur within the Rainbow Municipal Water District, Rainbow Municipal Water District or Valley Center Municipal Water District. Groundwater also is used on agricultural lands, especially for orchards in the Pauma area (San Diego County 2010). The Tribal lands also depend upon groundwater, including lands within the La Jolla Reservation, Los Coyotes Reservation, Pala Reservation, Pauma and Yuima Reservation, Rincon Reservation, and Santa Ysabel Reservation (San Diego County Water Authority et al. 2013).

There are three municipal water districts that overlie the San Luis Rey Valley GWB that manage water rights protection efforts. Groundwater is the only water supply within the Pauma Municipal Water District and the primary water supplies within the Mootamai Municipal Water District and the San Luis Rey Municipal Water District (San Diego Local Agency Formation Commission 2011; San Diego County Water Authority et al. 2013). The districts protect groundwater, surface water rights, and water storage and coordinate planning studies and legal activities within the San Luis Rey River watershed. Vista Irrigation District withdraws and stores groundwater in Lake Henshaw and withdraws groundwater in a GWSB located upgradient the San Luis Rey Valley GWB.

San Marcos, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley Groundwater Basins

The communities in the San Marcos, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley GWBs use a combination of surface water and groundwater to meet water demands (California Department of Water Resources 2010). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The Cities of Escondido and Poway; Ramona Municipal Water District, Rincon del Diablo Municipal Water District, Vallecitos Water District, and Vista ID; and private water companies provide retail water supplies to users within their communities. Groundwater use is small or does not occur within the Cities of Escondido and Poway, Ramona Municipal Water District, Rincon del Diablo Municipal Water District, and Vallecitos Water District. The Ramona Municipal Water District used to use groundwater until high nitrate concentrations required the district to abandon the wells.

Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Creek Groundwater Basins

The communities in the Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Creek GWBs primarily use surface water to meet water demands (California Department of Water Resources 2010; San Diego Local Agency Formation Commission 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. Groundwater use is limited to private wells within the Carlsbad Municipal Water District, including the City of

Carlsbad; Olivenhain Municipal Water District, including the Cities of Encinitas, Carlsbad, San Diego, Solano Beach, and San Marcos and the communities of Olivenhain, Leucadia, Elfin Forest, Rancho Santa Fe, Fairbanks Ranch, Santa Fe Valley, and 4S Ranch; San Dieguito Water District, including the communities of Encinitas, Cardiff-by-the-Sea, New Encinitas, and Old Encinitas; and Santa Fe Irrigation District, including the City of Solana Beach and the communities of Rancho Santa Fe and Fairbanks Ranch. Groundwater was used within the Carlsbad Municipal Water District area until high salinity caused the area to abandon the wells. Questhaven Municipal Water District manages groundwater for a recreation community located to the west of Escondido.

San Diego River Valley, El Cajon, and Mission Valley Groundwater Basins

The communities in the San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana GWBs use a combination of surface water and groundwater to meet water demands (California Department of Water Resources 2010; San Diego County Water Authority et al. 2013). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The City of San Diego, Helix Water District, and Sweetwater Authority provide retail surface water and/or groundwater supplies to users within the Cities of La Mesa, Lemon Grove, National City, and San Diego; portions of Chula Vista and El Cajon; and all or portions of the communities of Bonita, Lakeside, and Spring Valley. The County of San Diego-Campo Water and Sewer Maintenance District, Cuyamaca Water District, Decanso Community Services District, Julian Community Services District, Majestic Pines Community Services District, Wynola Water District, Lake Morena Oak Shores Mutual Water Company, Pine Hills Mutual Water Company, and Pine Valley Mutual Water Company rely upon groundwater to meet their water demands. Groundwater is not used for water supplies within Padre Dam Municipal Water District, which serves the City of Santee and portions of the City of El Cajon; Otay Water District, which serves portions of the Cities of Chula Vista, El Cajon, and La Mesa, and several unincorporated communities; and California American Water, which serves the City of Imperial Beach and portions of the Cities of Chula Vista, Coronado, and San Diego. Sweetwater Authority (SA) operates the Desalination Facility to treat brackish groundwater (Sweetwater Authority 2016).

I.1.8.4 Western Riverside County and Southwestern San Bernardino County

The areas within the SWP service area in western and central Riverside County and southern San Bernardino County in the Southern California Region include the Upper Santa Ana Valley GWB in Riverside and San Bernardino counties; the Elsinore Valley and San Jacinto GWBs in Riverside County; and the Temecula Valley GWB in Riverside and San Diego counties.

Hydrogeology and Groundwater Conditions

Upper Santa Ana Valley Groundwater Basin

The Upper Santa Ana Valley GWB consists of the Cucamonga, Chino, Riverside-Arlington, Temescal, Rialto-Colton, Cajon, Yucaipa, and San Timoteo GWSBs.

Cucamonga Subbasin

The Cucamonga GWSB is in San Bernardino County in the upper Santa Ana River watershed (California Department of Water Resources 2004; Metropolitan Water District of Southern California 2007). Groundwater is contained within the GWSB by the Red Hill fault. The water-bearing formations are mainly alluvium of gravel, sand, and silt with beds of compacted clay. Groundwater is recharged naturally from precipitation and stream flows, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates and localized areas with high volatile organic compounds, perchlorate, and DBCP (Metropolitan Water District of Southern California 2007).

SGMA designated the Cucamonga GWSB as very low priority (California Department of Water Resources 2020).

Chino Subbasin

The Chino GWSB is in San Bernardino County. The Chino GWSB is composed of alluvial material. The Rialto-Colton, San Jose, and the Cucamonga Faults act as groundwater flow barriers (California Department of Water Resources 2006). Along the southern boundary of the GWSB, groundwater can rise to the elevation of the Santa Ana River and be discharged into the stream. Groundwater is recharged naturally from precipitation and stream flows along the Santa Ana River and its tributaries, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water.

The Chino GWSB is characterized with high TDS and nitrate concentrations and localized areas of high volatile organic compounds, and perchlorate (Metropolitan Water District of Southern California 2007).

SGMA designated the Chino GWSB as very low priority (California Department of Water Resources 2020).

Riverside-Arlington Subbasin

The Riverside-Arlington GWSB is in the Santa Ana River Valley in southwestern San Bernardino County and northwestern Riverside County (California Department of Water Resources 2004). Water-bearing formations include alluvial deposits of sand, gravel, silt, and clay. The Rialto-Colton Fault separates this GWSB from the Rialto-Colton GWSB. The Riverside and Arlington portions of the GWSB are also separated. Groundwater flows to the northwest and to the Arlington Gap in the southwest area of the GWSB and continues into the Temescal GWSB. Groundwater is recharged naturally from precipitation and stream flows in the Santa Ana River and flow from adjacent GWSBs. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates and localized areas with high volatile organic compounds, perchlorate, and DBCP (Metropolitan Water District of Southern California 2007).

SGMA designated the Riverside-Arlington GWSB as very low priority (California Department of Water Resources 2020).

Temescal Subbasin

The Temescal GWSB is in the Santa Ana River Valley in Riverside County. Water-bearing formations consist of alluvium bounded by the Elsinore fault zone on the west and the Chino fault zone on the northwest (California Department of Water Resources 2006). Groundwater is recharged naturally from precipitation and stream flows in the tributaries of the Santa Ana River. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates and localized areas with high volatile organic compounds, perchlorate, iron, and manganese (Metropolitan Water District of Southern California 2007).

SGMA designated the Temescal GWSB as medium priority (California Department of Water Resources 2020).

Cajon Subbasin

The Cajon GWSB is in the upper Santa Ana River Valley in San Bernardino County. Water-bearing formations consist of alluvium bounded by the San Andreas Fault zone on the south and impermeable rock formations on the east and west (California Department of Water Resources 2004). Groundwater is recharged naturally from precipitation, stream flows in the tributaries of the Santa Ana River, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater quality is good for the beneficial uses.

SGMA designated the Cajon GWSB as very low priority (California Department of Water Resources 2020).

Rialto-Colton Subbasin

The Rialto-Colton GWSB is in the upper Santa Ana River Valley in southwestern San Bernardino and northwestern Riverside counties. Water-bearing formations consist of alluvium bounded by the Rialto-Colton and San Jacinto fault zones (California Department of Water Resources 2004). Groundwater is recharged naturally from precipitation and stream flows. The groundwater quality is good for the beneficial uses, with localized areas of high volatile organic compounds.

SGMA designated the Rialto-Colton GWSB as very low priority (California Department of Water Resources 2020).

Yucaipa Subbasin

The Yucaipa GWSB is in the upper Santa Ana River Valley in San Bernardino County. Water-bearing formations include alluvial deposits of sand, gravel, boulders, silt, and clay (California Department of Water Resources 2004). Several fault zones restrict groundwater movement. The San Timoteo formation along the western boundary of the basin causes the water to rise to the elevation of the San Timoteo Wash, a tributary of the Santa Ana River. Groundwater is recharged naturally from precipitation and stream flows, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with moderate TDS and high nitrate concentrations and localized areas with high volatile organic compounds.

SGMA designated the Yucaipa GWSB as high priority (California Department of Water Resources 2020).

San Timoteo Subbasin

The San Timoteo GWSB is in the upper Santa Ana River Valley in Riverside County. Water-bearing formations include alluvial deposits of gravel, silt, and clay (California Department of Water Resources 2004). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate and good quality for the beneficial uses.

SGMA designated the San Timoteo as very low priority (California Department of Water Resources 2020).

San Jacinto Groundwater Basin

The San Jacinto GWB is in the upper Santa Ana River Valley in Riverside County and underlies the San Jacinto, Perris, Moreno and Menifee Valleys and Lake Perris. The water-bearing formations are alluvium over crystalline basement rock (California Department of Water Resources 2006). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows along the San Jacinto River and its tributaries, percolation from Lake Perris, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with high TDS and nitrate concentrations and localized areas with high iron, manganese, sulfides, volatile organic compounds, and perchlorate (California Department of Water Resources 2006; Metropolitan Water District of Southern California 2007).

SGMA designated the San Jacinto GWB as high priority (California Department of Water Resources 2020).

Elsinore Groundwater Basin

The Elsinore GWB is in upper Santa Ana River Valley in Riverside County and contains two GWSBs: the Elsinore Valley and Bedford-Coldwater Groundwater Subbasins. The water-bearing formations are alluvial fan, floodplain, and lacustrine deposits underlain by alluvium of gravel, sand, silt, and clay (California Department of Water Resources 2006). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows along the San Jacinto River and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with moderate salinity and localized areas with high fluoride, arsenic, nitrate, iron, manganese, volatile organic compounds, and perchlorate (California Department of Water Resources 2006; Metropolitan Water District of Southern California 2007).

SGMA designated the Elsinore Valley GWSB as medium priority and the Bedford-Coldwater GWSB as very low priority (California Department of Water Resources 2020).

Temecula Valley Groundwater Basin

The Temecula Valley GWB is in the upper Santa Margarita River watershed within Riverside and San Diego counties. The water-bearing formations are alluvium of sand, tuff, and silt underlain by fractured bedrock (California Department of Water Resources 2004). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows. The groundwater is characterized as calcium-sodium bicarbonate with high TDS, fluoride, nitrate, volatile organic compounds, and perchlorate (California Department of Water Resources 2006; Metropolitan Water District of Southern California 2007).

SGMA designated the Temecula Valley GWB as very low priority (California Department of Water Resources 2020).

Groundwater Use and Management

Upper Santa Ana Valley Groundwater Basin

The Upper Santa Ana Valley GWB consists of the Cucamonga, Chino, Riverside-Arlington, Temescal, Rialto-Colton, Cajon, Yucaipa, and San Timoteo GWSBs.

Cucamonga and Chino Subbasins

The communities in the Cucamonga and Chino GWSBs use a combination of surface water and groundwater to meet water demands (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007). The Cities of Chino, Ontario, Pomona, and Upland; Cucamonga Valley Water District, Jurupa Community Services District, Monte Vista Water District, and Western Municipal Water District; and San Antonio Water Company, Fontana Water Company, Santa Ana River Water Company, and Marygold Mutual Water Company, and Golden State Water Company provide wholesale and/or retail water supplies, including groundwater, to users within their communities and to portions of the City of Rialto, Montclair, Rancho Cucamonga, and San Antonio Heights.

The Cucamonga GWSB was adjudicated in 1958 to allocate groundwater rights in the basin and surface water rights to Cucamonga Creek (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007). The water supplies are allocated to the Cucamonga Valley Water District, San Antonio Water Company, and the West End Consolidated Water Company. The City of Upland has agreements with the San Antonio Water Company and the West End Consolidated Water Company to divert from the GWSB.

The Chino GWSB was adjudicated in 1978 through the Chino Basin Judgment, which established the Chino Basin Watermaster to manage the GWSB and enforce the provisions of the judgment (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007). The judgment and subsequent agreements allocated the available safe yield to three categories, or pools: Overlying Agricultural Pool, including dairies, farms, and the State of California; Overlying Non-Agricultural Pool for industrial users; and the Appropriative Pool Committee, including local cities, public water agencies, and private water companies. The judgment and subsequent agreements included provisions for reallocation of water rights, groundwater replenishment if the GWSB is operated in a controlled overdraft condition, and development of a groundwater management plan. *Peace Agreements* adopted in 2000 and amended in 2004 included provisions to allow members of the Overlying Non-Agricultural Pool to transfer their water within their pool or to the Watermaster, appropriators to provide water service to overlying lands, and the Watermaster to allocate unallocated safe yield. The Peace Agreement also addressed use of local storage facilities and management of the GWSB under the Dry Year Yield program when imported water, including SWP water, is not fully available. Groundwater replenishment is allowed through spreading basins, percolation, groundwater injection, and in-lieu use of other water supplies, including SWP water. The Chino Basin Watermaster also was required to develop an optimum basin management plan, adopted in 1998, to address approaches that would enhance basin water supplies, protect and enhance water quality, enhance management of the basin, and equitably finance implementation of programs identified in the plan. The Peace II Agreement, adopted in 2007, addressed procedures related to basin reoperation under controlled overdraft conditions, using the Chino Desalters to meet the replenishment obligation and maintain hydraulic control in the GWSB, and transfers. The groundwater recharge master plan update was prepared by the Watermaster in 2010.

The Santa Ana Regional Water Quality Control Board adopted a water quality control plan in 2004 for the entire Santa Ana River Basin, which included a maximum benefit basin plan, recommended by the Chino Basin Watermaster and the Inland Empire Utilities Agency. The plan established water quality objectives in groundwater for TDS and total inorganic nitrogen and wasteload allocations to allow use of recycled water for groundwater recharge. The maximum benefit basin plan includes commitments for surface water and groundwater monitoring programs; implementation of up to 40 million gallons/day of treated groundwater at desalters; implementation of recharge facilities, conjunctive use programs, and recycled water quality management programs; and groundwater management to provide hydraulic controls to protect the Santa Ana River water quality.

Operations of the Chino Basin portion of the upper Santa Ana River are also affected by surface water rights judgments administered by the Santa Ana River Watermaster.

A large portion of the natural runoff in the upper Santa Ana River watershed is captured and used to recharge the groundwater aquifers. Flood control channels and percolation basins are operated by San Bernardino County Flood Control District to allow for flood control and groundwater recharge (Metropolitan Water District of Southern California 2007). Groundwater recharge also occurs in spreading basins operated by the City of Upland and San Antonio Water Company. The Chino Basin Water Conservation District operates percolation ponds and spreading basins to facilitate groundwater recharge (California Department of Water Resources 2010).

The Inland Empire Utilities Agency manages production and treatment of recycled water supplies that are used in groundwater recharge operations and as part of conjunctive use programs in the Cities of Chino, Chino Hills, Ontario, and Upland and in the service areas of the Cucamonga Valley Water District, Monte Vista Water District, Fontana Water Company, and San Antonio Water Company (California Department of Water Resources 2010). The district is a member of the Chino Basin Watermaster Board of Directors. The Inland Empire Utilities Agency operates several recharge facilities in the Chino GWSB. Recharge water comes from three sources: recycled water, stormwater, and imported SWP water. The Inland Empire Utilities Agency operates the Chino Desalter Authority's Chino I and Chino II Desalters that treat water from 22 wells. The Chino Desalter Authority is a joint powers authority that includes the Cities of Chino, Chino Hills, Norco, and Ontario and the Jurupa Community Services District, Santa Ana River Water Company, Western Municipal Water District, and Inland Empire Utilities Agency. The treated water from the desalters is used for potable water supplies, groundwater recharge with water with reduced salts and nitrates, and improved water quality of the Santa Ana River.

Riverside-Arlington and Temescal Subbasins

The communities in the Riverside-Arlington and Temescal GWSBs use a combination of surface water and groundwater to meet water demands (California Department of Water Resources 2010; City of Norco 2014; Metropolitan Water District of Southern California 2007). The San Bernardino Valley Municipal Water District and Western Municipal Water District provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Riverside-Arlington and Temescal GWSBs. The Cities of Colton, Corona, Norco, Rialto, and Riverside; Elsinore Valley Municipal Water District, Jurupa Community Services District, Lee Lake Water District; Rubidoux Community Services District, San Bernardino Valley Municipal Water District, Western Municipal Water District, and West Valley Water District; and Box Springs Mutual Water Company, Riverside Highland Mutual Water Company, and Terrace Water Company provide retail water supplies, including groundwater, to users within their communities. The Jurupa Community Services District uses wells within the Riverside-Arlington GWSB for nonpotable uses (California Department of Water Resources 2010).

The Riverside portion of the Riverside-Arlington GWSB was adjudicated in 1969 through the stipulated judgment for the *Western Municipal Water District of Riverside County et al. v. East San Bernardino County Water District et al.* The judgment provided average annual extraction volumes and replenishment schedules for the separate sections of the GWSB as defined by the San Bernardino County and Riverside County boundary (Riverside North and Riverside South portions of the GWSB) (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007). Within the Riverside North portion, the judgment affects only withdrawals that are to be used in Riverside County because withdrawals for use of water in San Bernardino County are not limited. The Western-San Bernardino Watermaster manages the monitoring and reporting of groundwater conditions of the Riverside portion of the GWSB.

The northern portion of the Riverside portion of the GWSB also was part of the 1969 judgment in the *Orange County Water District v. City of Chino et al.* This judgment primarily includes the Bunker Hill GWSB and small portions of the northern Riverside, Rialto-Colton, and Yucaipa GWSBs and requires minimum downstream flows into the lower Santa Ana River (California Department of Water Resources 2010). To meet the flow obligations, the San Bernardino Valley Municipal Water District is responsible to manage groundwater and surface waters within the San Bernardino Basin Area as defined in the judgment. The district manages the groundwater by allocation of groundwater withdrawal amounts and requiring replenishment when additional groundwater is withdrawn.

The Arlington portion of the Riverside-Arlington GWSB and the Temescal GWSBs are not adjudicated (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007). In 2008, an agreement was adopted between the Elsinore Valley Municipal Water District and the City of Corona for use of water from the southern portion of the Temescal GWSB.

The City of Riverside operates two water treatment plants as part of the North Riverside Water Project to remove volatile organic compounds. The City of Corona operates the Temescal Basin Desalter Treatment Plant/Facility, and Western Municipal Water District operates the Arlington Desalter (California Department of Water Resources 2010) to reduce TDS. The City of Norco operates a groundwater treatment plant to reduce iron, manganese, and hydrogen sulfide (City of Norco 2014).

Cajon, Rialto-Colton, Yucaipa, and San Timoteo Subbasins

The communities in the Cajon, Rialto-Colton, Yucaipa, and San Timoteo GWSBs use a combination of surface water and groundwater to meet water demands (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007; West Valley Water District 2014a). The San Bernardino Valley Municipal Water District and Western Municipal Water District provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Cajon, Rialto-Colton, Yucaipa, and San Timoteo GWSBs. The Cities of Colton, Loma Linda, Redlands, Rialto, Riverside, and San Bernardino; Beaumont-Cherry Valley Water District, East Valley Water District, South Mesa Water District, West Valley Water District, Western Municipal Water District, Walnut Valley Water District, and Yucaipa Valley Water District; and several private water companies provide retail water supplies, including groundwater, to users within their communities and to portions of the Cities of Beaumont, Calimesa, and Yucaipa; the communities of Cherry Valley, Mission Grove, Orange Crest, and Woodcrest; and numerous private water companies.

The Rialto-Colton GWSB was adjudicated in 1961 under the *Lytle Creek Water & Improvement Company v. Fontana Ranchos Water Company et al.* (California Department of Water Resources 2010). The adjudication allocated groundwater withdrawals between the Cities of Rialto and Colton, West Valley Water District, and Fontana Union Water Company based upon spring groundwater levels at three index wells between March and May of each water year. The GWSB is managed by the Rialto Basin Management Association. The stipulation of the judgment allocated groundwater withdrawal right to the City of Rialto, Citizens Land and Water Company, Lytle Creek Water and Improvement Company, and private well users. Use of this aquifer has been limited due to contamination with volatile organic compounds, which are currently being treated. The City of Rialto also has agreements with San Bernardino Municipal Water District to store SWP water in the Rialto GWSB. The city can withdraw the stored water without affecting the water allowed to be withdrawn under the 1961 decree.

As described under the *Riverside-Arlington and Temescal Subbasins* subsection, in 1969 there was a stipulated judgment for the *Western Municipal Water District of Riverside County et al. v. East San Bernardino County Water District et al.* to preserve the safe yield of the San Bernardino Basin Area through entitlements to groundwater withdrawals to protect the safe yield and establishment of replenishment schedules when the safe yield is exceeded (California Department of Water Resources 2010). The San Bernardino Basin Area includes portions of the Rialto-Colton and Yucaipa GWSBs and portions of the Mill Creek, Lytle Creek, and upper Santa Ana River watersheds. The Western-San Bernardino Watermaster, which includes the Western Municipal Water District and San Bernardino Municipal Water District, manages the monitoring and reporting of groundwater conditions. The primary users of the groundwater under this decree include the Cities of Colton, Loma Linda, Redlands, and Rialto; East Valley Water District, San Bernardino Municipal Water District, West Valley Water District, and Yucaipa Valley Water District; and Riverside-Highland Water Company and 13 private water companies.

In 2002, the City of Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District formed the San Timoteo Watershed Management

Authority to enhance water supplies and water quality, manage groundwater in the Beaumont Basin (part of the San Timoteo GWSB, protect riparian habitat in San Timoteo Creek, and allocate benefits and costs of these programs (Beaumont Basin Watermaster 2013; California Department of Water Resources 2010). One of the issues that the authority initiated was negotiations related to groundwater withdrawals by the City of Banning. A Stipulated Agreement was adopted in 2004 in accordance with the judgment for the *San Timoteo Watershed Management Authority v. City of Banning et al.* The judgment established a Watermaster committee of the Cities of Banning and Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District. The judgment allocated groundwater supplies in a manner that allows for storage of groundwater recharge from spreading basins or in-lieu programs.

The Seven Oaks Accord, a settlement agreement, was signed by the City of Redlands; East Valley Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District; and Bear Valley Mutual Water Company, Lugonia Water Company, North Fork Water Company, and Redlands Water Company to recognize prior rights of water users to a portion of the natural flow of the Santa Ana River (California Department of Water Resources 2010). The Seven Oaks Accord requires that the San Bernardino Valley Municipal Water District, and Western Municipal Water District develop a groundwater spreading program, in cooperation with other parties to the accord, to recharge the groundwater to maintain relatively constant groundwater levels.

In 2005, the San Bernardino Valley Municipal Water District entered into an agreement with the San Bernardino Valley Water Conservation District to work cooperatively to develop and implement a groundwater management plan, which includes groundwater banking programs (California Department of Water Resources 2010).

The City of Rialto, San Bernardino Valley Municipal Water District, West Valley Water District, and Riverside Highland Water District have jointly constructed the Baseline Feeder to convey groundwater to the Rialto area and West Valley Water District to be used in an in-lieu program that would reduce reliance on SWP water supplies (California Department of Water Resources 2010; West Valley Water District 2014b, 2014c).

West Valley Water District implemented a bioremediation wellhead treatment system (West Valley Water District 2014b).

San Jacinto Groundwater Basin

The communities in the San Jacinto GWB use a combination of surface water and groundwater to meet water demands (California Department of Water Resources 2010; Metropolitan Water District of Southern California 2007). The Eastern Municipal Water District provides wholesale and retail water supplies, including groundwater, in the areas that overlay the San Jacinto GWB. The Cities of Hemet and San Jacinto and Eastern Municipal Water District and Rancho California provide retail water supplies, including groundwater, to users within their communities and to portions of the Cities of Menifee, Moreno Valley, Murrieta, and Temecula; Lake Hemet Municipal Water District; Nuevo Water Company and numerous private water companies; and the communities of Edgemont, Homeland, Juniper Flats, Lakeview, Mead Valley, North Perris Water System, Romoland, Sunnymead, Valle Vista, and Winchester. The

City of Perris overlays a portion of the San Jacinto GWB; however, the city does not use groundwater. A substantial portion of the groundwater supplies within the San Jacinto GWB are used by agricultural water users.

The 1954 Fruitvale Judgment allows for the Eastern Municipal Water District to withdraw water from the San Jacinto GWB if the groundwater elevation is greater than a specified elevation (California Department of Water Resources 2010; Eastern Municipal Water District 2009, 2014). The judgment includes a maximum withdrawal volume for use outside of the GWB. There are further restrictions within the Canyon Basin GWSB of the San Jacinto Groundwater Basin. DWR worked with the Cities of Hemet and San Jacinto, Lake Hemet Municipal Water District, Eastern Municipal Water District, and private groundwater companies to file a stipulated judgment in 2007 to form a Watermaster to develop and implement the Hemet/San Jacinto Water Management Plan, including the Hemet/San Jacinto Integrated Recharge and Recovery Program, Recycled Water In-Lieu Project, and Hemet Filtration Plant. The stipulated judgment also limited groundwater withdrawals to protect the GWB, provide for recharge programs, expand water production, and protect water quality. The program uses SWP water and San Jacinto River runoff to recharge the San Jacinto-Upper Pressure Groundwater Management Zone. In 2013, the judgment was filed with the court to adopt the Hemet/San Jacinto Water Management Plan and create the Watermaster Board.

The stipulated judgment also addressed methods to fulfil the Soboaba Band of Luiseño Indians water rights in accordance with the findings of the Court for the *Soboba Band of Luiseño Indians Water Settlement Agreement* in 2006. In 2008, the Soboba Settlement Act was signed by the President of the United States to provide an annual water supply and provide funds for economic development. The legislation also provides funds to construct recharge facilities and provisions for the Soboba Tribe to participate in restoration efforts.

The Eastern Municipal Water District adopted the West San Jacinto Groundwater Basin Management Plan in 1995. The management plan includes the Nuevo Water Company, City of Moreno Valley, City of Perris, and McCanna Ranch Water Company (Metropolitan Water District of Southern California 2007).

The Eastern Municipal Water District operates two desalination plants to treat brackish water within the San Jacinto GWB as part of the Groundwater Salinity Management Program (California Department of Water Resources 2010). Other wells within the Eastern Municipal Water District also include treatment facilities to reduce hydrogen sulfide, iron, and/or manganese.

Elsinore Groundwater Basin

The communities in the Elsinore GWB use a combination of surface water and groundwater to meet water demands (Metropolitan Water District of Southern California 2007). The Elsinore Valley Municipal Water District provides wholesale and retail water supplies, including groundwater, in the areas that overlay the Elsinore GWB. The Cities of Lake Elsinore, Canyon Lake, and Wildomar; Elsinore Valley Municipal Water District and Elsinore Water District; and Farm Mutual Water Company provide retail water supplies, including groundwater, to users within their communities and to portions of Cleveland Ranch, Farm, Horsethief Canyon, Lakeland Village, Meadowbrook, Rancho Capistrano – El Cariso Village, and Temescal Canyon.

The Elsinore GWB is not adjudicated. The Elsinore Valley Municipal Water District was responsible for over 90% of the groundwater withdrawals in mid-2000s (California Department of Water Resources 2010). The Elsinore Basin Groundwater Management Plan, adopted by the Elsinore Valley Municipal Water District in 2005, identifies conjunctive use projects, including direct recharge projects. The direct recharge projects use imported water, including SWP water.

Temecula Valley Groundwater Basin

The communities in the Temecula Valley GWB use a combination of surface water and groundwater to meet water demands (Metropolitan Water District of Southern California 2007; California Department of Water Resources 2010). The Rancho California Water District and Western Municipal Water District (including Murrieta County Water District) provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Temecula Valley GWB, including the Cities of Murrieta and Temecula. The Pechanga Indian Reservation operates groundwater wells within the Temecula Valley GWB (Metropolitan Water District of Southern California 2007).

The Temecula Valley GWB is in the Santa Margarita River watershed. As described for the San Mateo Valley, San Onofre Valley, and Santa Margarita Valley GWBs, the GWBs that contribute direct or indirect flows into the Santa Margarita River have been adjudicated and are managed by the Santa Margarita River Watermaster in accordance with the 1940 Stipulated Judgment, the 1966 Modified Final Judgment and Decree, and subsequent court orders (Metropolitan Water District of Southern California 2007; California Department of Water Resources 2010; Santa Margarita River Watershed Watermaster 2011). The court-appointed steering committee for the Watermaster includes the Eastern Municipal Water District, Fallbrook Public Utility District, Metropolitan Water District of Southern California, Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation, Rancho California Water District, Western Municipal Water District, and Marine Corps Base Camp Pendleton. In accordance with the judgment, the Rancho California Water District prepares the annual groundwater audit and recommended groundwater production report that allocates groundwater withdrawals based upon rainfall, recharge area, and pumping capacity. The subsequent orders adopted following 1966 included the Cooperative Water Resource Management Agreement between the Rancho California Water District and the Marine Corps Base Camp Pendleton to manage groundwater levels and surface water flows; water rights to Vail Lake on Temecula Creek; and an agreement between the Rancho California Water District and the Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation.

The Rancho California Water District provides imported water, including SWP water, and natural runoff released from Vail Lake to the Valle de Los Caballos Recharge Basins (California Department of Water Resources 2010). The district also has implemented the Vail Lake Stabilization and Conjunctive Use Project to store imported water in Vail Lake for subsequent groundwater recharge (Rancho California Water District et al. 2014).

I.1.8.5 Central Riverside County

The areas within the SWP service area that receive Colorado River water in-lieu of SWP water deliveries are located within the Coachella Valley GWB. The Coachella Valley GWB includes the Desert Hot Springs, Indio, Mission Creek, and San Gorgonio Pass GWSBs.

Hydrogeology and Groundwater Conditions

The Coachella Valley GWB underlies the entire floor of the Coachella Valley. Primary water-bearing materials in the Coachella Valley GWB are unconsolidated alluvial deposits along the valley floor, which consist of older alluvium and a thick sequence of poorly bedded coarse sand and gravel, terrace deposits under the surrounding foothills in the Mission Creek GWSB, and partly consolidated fine to coarse sandstone in the surrounding mountains in the San Gorgonio Pass GWSB (California Department of Water Resources 2004). The movement of groundwater is locally influenced by features such as faults, structural depressions, and constrictions; however, groundwater generally flows to the southeast toward the Salton Sea. Groundwater recharge occurs along streambeds and from groundwater inflows from adjacent GWSBs. Within the Indio GWSB, groundwater also is recharged from spreading basins and injection wells.

The groundwater quality is characterized as calcium-sodium bicarbonate. Groundwater quality is adequate for community and agricultural water uses within the San Gorgonio Pass, Mission Creek, and Indio GWSBs. There are localized areas with high fluoride near the Banning and San Andreas fault zones. Groundwater quality in the Desert Hot Springs GWSB is poor due to the geothermal activity that results in high sodium sulfate, TDS, and chlorides. The hot springs water is only used by a resort for bathing.

SGMA designated the Desert Hot Springs GWB as very low priority. Indio, Mission Creek, and San Gorgonio Pass GWBs were designated as medium priority (California Department of Water Resources 2020).

Groundwater Use and Management

Coachella Valley Groundwater Basin

The Coachella Valley GWB includes the San Gorgonio Pass, Mission Creek, Desert Hot Springs, and Indio GWSBs.

San Gorgonio Pass Subbasin

The communities in the San Gorgonio Pass GWSB use a combination of surface water and groundwater to meet water demands (California Department of Water Resources 2010). The City of Banning, Beaumont-Cherry Valley Water District, Cabazon Water District, and High Valley Water District provide retail water supplies, including groundwater, in the areas that overlay the San Gorgonio Pass GWSB, including the City of Banning and the eastern portion of the City of Beaumont; Banning Heights Mutual Water Company; and the community of Cabazon. The Morongo Band of Mission Indians operates groundwater wells within the San Gorgonio Pass GWSB.

The western portion of the San Gorgonio Pass GWSB is in the Beaumont Basin (U.S. Geological Survey 1974). The City of Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District formed the San Timoteo Watershed Management Authority to enhance water supplies and water quality, manage groundwater, protect riparian habitat in San Timoteo Creek, and allocate benefits and costs of these programs (Beaumont Basin Watermaster 2013). One of the issues that the authority initiated was negotiations related to groundwater withdrawals by the City of Banning. A Stipulated Agreement was adopted in 2004 in accordance with the judgment for the *San Timoteo Watershed Management Authority v. City of Banning et al.* The judgment established a Watermaster committee of the Cities of Banning and Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District. The judgment allocated groundwater supplies in a manner that allows for storage of groundwater recharge from spreading basins or in-lieu programs.

Mission Creek, Desert Hot Springs, and Indio Subbasins

The communities in the Mission Creek, Desert Hot Springs, and Indio GWSBs use a combination of surface water and groundwater to meet water demands (California Department of Water Resources 2010; Coachella Valley Water District 2012). The City of Coachella, Coachella Valley Water District, Desert Water Agency, Indio Water Authority, and Mission Springs Water District provide retail water supplies, including groundwater, in the areas that overlay the Mission Creek, Desert Hot Springs, and Indio GWSBs, including the Cities of Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage and the communities of Barton Canyon, Bermuda Dunes, Bombay Beach, Desert Crest, Desert Edge, Indio Hills, Mecca, Mecca Hills, Palm Springs Crest, Salton City, Thermal, and West Palm Springs Village. The Cabazon Band of Mission Indians and the Torres-Martinez Desert Cahuilla Indians operate groundwater wells within the GWSBs.

The Coachella Valley Water District, Desert Water Agency, and Mission Springs Water District all participate in groundwater management programs within the GWSBs (California Department of Water Resources 2010; Coachella Valley Water District 2012). These programs include purchasing imported Colorado River water for groundwater recharge and in-lieu programs, conjunctive use programs, and conservation programs. The Coachella Valley Water District and Desert Water Agency are SWP water contractors. However, because no conveyance facilities exist to deliver the SWP water, these districts have agreements with the Metropolitan Water District of Southern California to exchange SWP water for Colorado River water (Coachella Valley Water District 2012). Since 1973, these agencies have recharged more than 2.6 million AF in the GWB with delivery of Colorado River water to the Whitewater River Recharge Facility. The Metropolitan Water District of Southern California also has an agreement with the Coachella Valley Water District and Desert Water Agency to store water in the Coachella Valley GWB. The Coachella Valley Water District also operates the Thomas E. Levy Groundwater Replenishment Facility and the Martinez Canyon Pilot Recharge Facility. Coachella Valley Water District and Desert Water Agency also provide recycled water for in-lieu programs. Coachella Valley Water District has agreed to operate groundwater recharge facilities to store Colorado River water for Imperial Irrigation District (California Department of Water Resources 2010).

These groundwater recharge programs and broader groundwater management programs for the Indio GWSB have been developed in accordance with the Whitewater Basin Water Management Plan developed by the Coachella Valley Water District and Desert Water Agency and the Coachella Valley Water Management Plan developed by the Coachella Valley Water District (California Department of Water Resources 2010; Coachella Valley Water District 2012).

The Coachella Valley Water District, Desert Water Agency, and Mission Springs Water District jointly manage the Mission Creek GWSB in accordance with the 2004 Mission Creek Settlement Agreement (California Department of Water Resources 2010). The Coachella Valley Water District and Desert Water Agency also manage portions of the GWSB in accordance with the 2003 Mission Creek Groundwater Replenishment Agreement. These agreements provide for the allocation of available Colorado River water under the SWP water exchange agreement with the Metropolitan Water District of Southern California between the Mission Creek and Indio (also known as the Whitewater) GWSBs.

I.1.8.6 Antelope Valley and Mojave Valley

The areas within the SWP service area in the Antelope Valley and Mojave Valley include Salt Wells Valley, Cuddeback Valley, Pilot Knob Valley, Grass Valley, Superior Valley, El Mirage Valley, Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, Caves Canyon Valley, Langford Valley, Cronise Valley, Coyote Lake Valley, Kane Wash Area, Iron Ridge Area, Bessemer Valley, Lucerne Valley, Johnson Valley, Means Valley, Deadman Valley, Twentynine Palms Valley, Joshua Tree, Ames Valley, Copper Mountain Valley, Warren Valley, and Morongo Valley GWBs in San Bernardino County; Harper Valley and Fremont Valley GWBs in San Bernardino and Kern counties; Lost Horse Valley in Riverside and San Bernardino counties; Antelope Valley GWB in San Bernardino, Kern, and Los Angeles counties; and Indian Wells and Searles Valley GWBs in San Bernardino, Inyo, and Kern counties.

Hydrogeology and Groundwater Conditions

Indian Wells Valley Groundwater Basin

Indian Wells Valley GWB is in Inyo, Kern, and San Bernardino counties. Water-bearing formations consist of unconsolidated lakebed, stream, and alluvial fan deposits with upper and lower aquifers (California Department of Water Resources 2004). The lower aquifer is more productive and has a saturated thickness of approximately 1,000 feet. The upper aquifer provides low yield and has low quality. The lower aquifer is considered unconfined in most of the valley. There is indication that some faults within the valley could obstruct groundwater flow. Groundwater is recharged from runoff on the southwest to northeast sides of the valley. Groundwater levels have been declining since 1945. Groundwater quality varies throughout the GWB from appropriate for beneficial uses to areas with poor water quality because of wastewater disposal practices. Areas near geothermal activity are characterized by high chloride, boron, and arsenic concentrations.

SGMA designated the Indian Wells Valley GWB as high priority (California Department of Water Resources 2020).

Salt Wells Valley Groundwater Basin

Salt Wells Valley GWB is in San Bernardino County. Water-bearing formations consist of unconsolidated to poorly consolidated alluvium (California Department of Water Resources 2004). Groundwater is recharged from the Indian Wells GWB and percolation of rainfall on the valley floor. The regional groundwater flow direction is toward the east into the Searles Valley GWB. The groundwater has extremely high salinity, TDS, and boron.

SGMA designated the Salt Wells Valley GWB as very low priority (California Department of Water Resources 2020).

Searles Valley Groundwater Basin

Searles Valley GWB is in San Bernardino, Inyo, and Kern counties. Water-bearing formations consist of alluvium with unconsolidated to semiconsolidated deposits (California Department of Water Resources 2004). The Garlock fault may be a barrier to groundwater flow in the southern part of the basin. Groundwater is recharged from percolation of mountain runoff through the alluvial fan deposits and subsurface inflow from Salt Wells Valley and Pilot Knob Valley GWBs. Groundwater flows toward Searles Lake except in the northern portion of the basin where pumping by industrial water users has altered the groundwater flow. Groundwater levels near Searles Lake are close to the lakebed elevations. Groundwater quality is generally appropriate for beneficial uses, with localized areas with high levels of fluoride and nitrate. In the vicinity of Searles Lake, the groundwater quality is poor, with high levels of fluoride, boron, sodium, chloride, sulfate, and TDS.

SGMA designated the Searles Valley GWB as very low priority (California Department of Water Resources 2020).

Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley Groundwater Basins

Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley GWBs are in northern San Bernardino County. Water-bearing formations consist of unconsolidated to poorly consolidated alluvium (California Department of Water Resources 2004). Several fault zones restrict groundwater movement. Groundwater is recharged in the Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley GWBs primarily through groundwater inflow into the basins and percolation of precipitation at the valley margins. Groundwater within Cuddeback Valley, Grass Valley, and Superior Valley GWBs flows toward the Harper Valley GWB. Groundwater in the Cuddeback Valley GWB also flows toward Cuddeback Lake. Groundwater in Pilot Knob Valley GWB flows toward the Searles Valley and Brown Mountain Valley GWBs. Groundwater quality is characterized as sodium chloride-bicarbonate with high salinity and TDS in the Cuddeback Valley GWB and high concentrations of sodium and fluoride in the Superior Valley GWB.

SGMA designated the Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley GWBs as very low priority (California Department of Water Resources 2020).

Harper Valley Groundwater Basin

Harper Valley GWB is in western San Bernardino and eastern Kern counties. Water-bearing formations consist of lacustrine deposits and unconsolidated to semiconsolidated alluvial deposits (California Department of Water Resources 2004). The alluvial deposits at the center of the basin are generally more interbedded with lacustrine silty clay. Faults in the Harper Valley GWB cause at least partial barriers to groundwater flow. Groundwater is recharged from percolation of rainfall and runoff through alluvial fan material at the valley edges and underflow from Cuddeback Valley, Grass Valley, Superior Valley, and Middle Mojave River Valley GWBs. Regional groundwater flows toward the south and Harper Lake. Groundwater quality is characterized as sodium chloride-bicarbonate with high concentrations of boron, fluoride, and sodium.

SGMA designated the Harper Valley GWB as very low priority (California Department of Water Resources 2020).

Fremont Valley Groundwater Basin

The Fremont Valley GWB is in eastern Kern and northwestern San Bernardino counties. Water-bearing formations consist of alluvial and lacustrine deposits (California Department of Water Resources 2004). The alluvial deposits are generally unconfined, and the lacustrine deposits may exhibit locally confined conditions. Fault zones, including the Garlock and El Paso fault zones, are barriers to groundwater flow. Groundwater is recharged along streambeds in the Sierra Nevada Mountains. Groundwater flow is generally toward the center of the valley and Koehn Lake. Groundwater is characterized as sodium bicarbonate with high concentrations of calcium, chloride, fluoride, and sodium.

SGMA designated the Fremont Valley GWB as low priority (California Department of Water Resources 2020).

Antelope Valley Groundwater Basin

The Antelope Valley GWB is in Kern, Los Angeles, and San Bernardino counties. Water-bearing formations consist of unconsolidated alluvial and lacustrine deposits consisting of compact gravels, sand, silt, and clay (California Department of Water Resources 2004). Several fault zones restrict groundwater movement. Groundwater is recharged along streams from the surrounding mountains, including Big Rock Creek and Little Rock Creek. The regional groundwater flow direction historically was toward the dry lakebeds of Rosamond, Rogers, and Buckhorn Lakes. However, extensive groundwater pumping has caused subsidence and reduced the groundwater storage and flow direction. The groundwater is characterized as sodium bicarbonate, with localized areas of high nitrate and boron.

SGMA designated the Antelope Valley GWB as very low priority (California Department of Water Resources 2020).

El Mirage Valley Groundwater Basin

The El Mirage Valley GWB is in Los Angeles and San Bernardino counties. Water-bearing formations consist of unconsolidated to semiconsolidated alluvium (California Department of Water Resources 2003). Several fault zones restrict groundwater movement. Groundwater is recharged in alluvial deposits at the mouth of Sheep Creek. The regional groundwater flow direction is generally north toward El Mirage Lake. The groundwater is characterized as sodium bicarbonate, with localized areas of high levels of fluoride, sulfate, sodium, and TDS.

SGMA designated the El Mirage Valley GWB as very low priority (California Department of Water Resources 2020).

Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley Groundwater Basins

The Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley GWBs are located along the Mojave River in southwestern and central San Bernardino County. The water-bearing formations consist of alluvial fan deposits overlain by river channel, floodplain, or lake deposits (California Department of Water Resources 2003, 2004). The general groundwater flow direction follows the Mojave River north through the Upper Mojave River Valley GWB and east through the Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley GWBs. Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation on the valley floor, underflow from the Mojave River, streamflow, and flow between the basins. Treated wastewater and irrigation return flows also provide a source of groundwater recharge in these basins. Groundwater quality in the Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley GWBs varies throughout the basins due to geological formations and includes areas dominated by calcium bicarbonate, calcium-sodium bicarbonate, calcium-sodium sulfate, sodium-calcium sulfate, and sodium sulfate-chloride. There are localized areas of high nitrate, iron, and manganese in the Upper Mojave River Valley GWB and areas with high nitrates, fluoride, and boron in the Middle Mojave River Valley and Lower Mojave River Valley GWBs. Localized areas with high volatile organic compounds occur in the Upper Mojave River Valley and Lower Mojave River Valley GWBs.

SGMA designated the Upper Mojave River Valley GWB as very low priority. The Lower Mojave River Valley GWB was designated as very low priority also. The Middle Mojave River Valley GWB was designated as very low priority, and the Caves Canyon Valley GWB was designated as very low priority as well (California Department of Water Resources 2020).

Langford Valley Groundwater Basin–Langford Well Lake Subbasin, and Cronise Valley and Coyote Lake Valley Groundwater Basins

The Langford Well Lake GWSB and the Cronise Valley and Coyote Lake Valley GWBs are located in central San Bernardino County. Water-bearing formations consist of unconsolidated to semiconsolidated alluvium (California Department of Water Resources 2004). Groundwater is recharged from precipitation, stream flows into alluvial deposits along the mountains at the basin boundaries, and subsurface inflow from other GWBs, including the Superior Valley GWB. Groundwater quality is poor due to high concentrations of fluoride, boron, and TDS and localized areas with high iron in the Langford Well Lake GWSB.

SGMA designated the Langford Well Lake GWSB, the Cronise Valley, and Coyote Lake Valley GWBs as very low priority (California Department of Water Resources 2020).

Kane Wash Area Groundwater Basin

The Kane Wash Area GWB is in San Bernardino County. Water-bearing formations consist of unconsolidated to semiconsolidated alluvium with undissected coarse gravel to sand in the younger deposits and dissected gravel sand and silt in the older deposits (California Department of Water Resources 2004). Groundwater is recharged from precipitation and stream flows. The groundwater is characterized as sodium sulfate-bicarbonate with moderate TDS concentrations.

SGMA designated the Kane Wash Area GWB as very low priority (California Department of Water Resources 2020).

Iron Ridge Area Groundwater Basin

The Iron Ridge Area GWB is in southern San Bernardino County. Water-bearing formations consist of unconsolidated to semiconsolidated alluvium (California Department of Water Resources 2004). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows from the nearby mountains.

SGMA designated the Iron Ridge Area GWB as very low priority (California Department of Water Resources 2020).

Bessemer Valley Groundwater Basin

The Bessemer Valley GWB is in eastern San Bernardino County. Water-bearing formations consist of unconsolidated to semi-consolidated alluvial deposits, fanglomerate, and playa lake deposits (California Department of Water Resources 2004). More recent deposits consist of unconsolidated, undissected coarse gravel to sand. Older deposits consist of gravel, sand, and silt from dissected alluvial fans. Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows at the valley margins.

SGMA designated the Bessemer Valley GWB as very low priority (California Department of Water Resources 2020).

Lucerne Valley Groundwater Basin

The Lucerne Valley Groundwater basin is in San Bernardino County. Water-bearing formations consist of unconsolidated or semi-consolidated alluvial deposits and dune sand deposits composed of gravel, sand, silt, clay, and occasional boulders (California Department of Water Resources 2004). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows. Groundwater levels have declined throughout the basin and caused subsidence. The groundwater is characterized as calcium-magnesium bicarbonate or magnesium-sodium sulfate with TDS and nitrates.

SGMA designated the Lucerne Valley GWB as very low priority (California Department of Water Resources 2020).

Johnson Valley Groundwater Basin

The Johnson Valley GWB is in San Bernardino County and includes the Soggy Lake and Upper Johnson Valley GWSBs. Water-bearing formations in both GWSBs consist of alluvial deposits with mainly sand and gravel in the Soggy Lake GWSB and silt, clay, sand, and gravel in the Upper Johnson Valley GWSB (California Department of Water Resources 2004). Springs occur throughout the Soggy Lake GWSB. Groundwater flows from Soggy Lake GWSB into the Upper Johnson Valley GWSB. Several fault zones restrict groundwater movement. The groundwater is characterized with moderate to high TDS and localized areas with high fluoride.

SGMA designated the Johnson Valley GWB as very low priority (California Department of Water Resources 2020).

Means Valley Groundwater Basin

The Means Valley GWB is in south central part of San Bernardino County. Water-bearing formations consist of alluvial and lacustrine deposits with unconsolidated fine- to coarse-grained sand, pebbles, and boulders and varying silt and clay deposits throughout the basin (California Department of Water Resources 2004). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and subsurface inflow from the Johnson Valley GWB. The groundwater is characterized as sodium-chloride bicarbonate with high TDS, fluoride, and nitrates.

SGMA designated the Means Valley GWB as very low priority (California Department of Water Resources 2020).

Deadman Valley Groundwater Basin

The Deadman Valley GWB is in San Bernardino County. The Deadman Valley GWB includes the Deadman Lake and Surprise Spring GWSBs. Water-bearing formations consist of unconsolidated to partly consolidated continental deposits, including interbedded gravels, conglomerates, clays, and silts in alluvial fan units (California Department of Water Resources 2004). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows. Groundwater flows from the Surprise Spring GWSB into the Deadman Lake GWSB and from Deadman Lake GWSB to the dry Mesquite Lake. Groundwater also flows from the Ames Valley GWB into the Surprise Spring GWSB. The groundwater is characterized as sodium bicarbonate with moderate to high TDS and localized areas of high fluoride.

SGMA designated the Deadman Valley GWB as very low priority (California Department of Water Resources 2020).

Twentynine Palms Valley, Joshua Tree, Ames Valley, Copper Mountain Valley, and Warren Valley Groundwater Basins

The Twentynine Palms Valley, Ames Valley, and Copper Mountain Valley GWBs are in southern San Bernardino County. The Joshua Tree and Warren Valley GWBs are in southern San Bernardino County and northern Riverside County. Water-bearing formations consist of unconfined, unconsolidated to partly consolidated continental deposits with interbedded gravels, conglomerates, lake playa, silts, clays, and sandy-clay deposits (California Department of Water

Resources 2004). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation, stream flows, and wastewater effluent disposal. Groundwater flows from the Joshua Tree GWB into the Copper Mountain Valley GWB. Groundwater recharge in the Warren Valley GWB also occurs at spreading grounds. The groundwater is characterized as calcium-sodium bicarbonate or sodium sulfate with moderate to high TDS in all of the basins except the Copper Mountain Valley GWB and localized areas with high fluoride, nitrate, sulfate, and chloride.

SGMA designated the Warren Valley GWB as very low priority. Twentynine Palms Valley was designated as very low priority. Joshua Tree, Ames, and Copper Mountain Valley GWBs were also designated as very low priority (California Department of Water Resources 2020).

Morongo Valley Groundwater Basin

The Morongo Valley Groundwater basin is in southern San Bernardino County. Water-bearing formations consist of alluvial deposits composed of sand, gravel, silt, and clay (California Department of Water Resources 2003). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows in the Big Morongo and Little Morongo creeks. The groundwater is characterized as calcium-sodium bicarbonate with moderate TDS.

SGMA designated the Morongo Valley GWB as very low priority (California Department of Water Resources 2020).

Lost Horse Valley Groundwater Basin

The Lost Horse Valley GWB is located on the border between southeastern San Bernardino County and northeastern Riverside County. Water-bearing formations consist of unconsolidated to semiconsolidated alluvial deposits (California Department of Water Resources 2004). Groundwater is recharged from precipitation and stream flows.

SGMA designated the Lost Horse Valley GWB as very low priority (California Department of Water Resources 2020).

Groundwater Use and Management

Within the Antelope Valley and Mojave Valley, groundwater management is facilitated by the Antelope Valley-East Kern Water Agency and Mojave Water Agency. These agencies purchase SWP water and other water supplies to be used for groundwater recharge or in-lieu uses to protect groundwater within the Antelope and Mojave Valleys.

Antelope Valley

The Antelope Valley-East Kern Water Agency provides SWP water to areas that overlay portions of the Antelope Valley, Fremont Valley, and Indian Wells Valley GWBs. To maintain groundwater aquifers in the area, the Antelope Valley-East Kern Water Agency provides treated SWP water to users through the domestic-agricultural water network and untreated SWP water to some agricultural users (California Department of Water Resources 2010). The Antelope Valley-East Kern Water Agency participates in groundwater banking programs. Communities within the Antelope Valley-East Kern Water Agency service area also use groundwater, including the Cities of California City, Lancaster, and Palmdale; Edwards Air Force Base; County of Los Angeles

Waterworks District No. 40; Boron Community Services District, Desert Lake Community Services District, Indian Wells Water District (including the City of Ridgecrest), Mojave Public Utilities District, Palmdale Water District, Palm Ranch Irrigation District, Quartz Hill Water District, and Rosamond Community Services District; and California Water Service Company (Antelope Valley, Lake Hughes, areas outside of the City of Lancaster, and Leona Valley), Edgemont Crest Municipal Water Company, El Dorado Mutual Water Company, Lake Elizabeth Mutual Water Company, Shadow Acres Mutual Water Company, Sunnyside Farm Mutual Water Company, Westside Park Mutual Water Company, and White Fence Farms Mutual Water Company provide retail groundwater supplies.

In 2004, the County of Los Angeles Waterworks District No. 40 and Palmdale Water District filed for the adjudication of the Antelope Valley GWB (California Department of Water Resources 2014c; California Department of Water Resources 2010). The request of the filing is to allocate groundwater rights within the basin to these districts, other municipal and industrial water users, and overlying landowners and provide for a program to replace groundwater withdrawals in excess of a specified yield in order to stabilize or reverse groundwater declines.

Mojave Valley

Within the Mojave Water Agency service area, most of the water supply is from groundwater (California Department of Water Resources 2010; Twentynine Palms Water District 2014). The Mojave Water Agency uses natural surface water flows, recycled water imported from outside of the agency's service area, SWP water, and return flows from water users of groundwater within the service area to recharge groundwater. These water supplies are provided as wholesale water supplies to retail groundwater users to maintain groundwater levels in the area. The Mojave Water Agency overlays all or portions of all of the GWBs described in this subsection. The City of Adelanto; Hesperia Water District, Hi-Desert Water District, Joshua Water District, Twentynine Palms Water District, Victorville Water District, Apple Foothill County Water District, Apple Heights County Water District, Juniper Riviera County Water District, Thunderbird County Water District, Daggett Community Services District, Helendale Community Services District, Phelan Piñon Hills Community Services District, Yermo Community Services District, Bighorn-Desert View Water Agency, and San Bernardino County Service Areas numbers 64 and 70; and Golden State Water Company, Apple Valley Ranchos Water Company, Jubilee Water Company, and Rancheritos Mutual Water Company provide retail groundwater supplies. These entities provide water to the Cities of Adelanto, Barstow, Hesperia, Twentynine Palms, Victorville; towns of Apple Valley and Yucca; Joshua Tree National Park; Twentynine Palms Marine Corps Base; and the communities of Apple Heights, Apple Valley, Daggett, Flamingo Heights, Helendale, Johnson Valley, Landers, Lucerne Valley, Newberry Springs, Oak Hills, Spring Valley Lake, Yermo, and users between these communities. The Morongo Band of Mission Indians also rely upon groundwater from this area.

The Mojave Water Agency has implemented 13 groundwater recharge facilities (California Department of Water Resources 2010). The SWP water is delivered to the recharge facilities throughout the Mojave Water Agency service area.

The area known as the Mojave Basin Area has been adjudicated. This area includes all or portions of Cuddeback Valley, Superior Valley, Harper Valley, Antelope Valley, El Mirage Valley, Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, Caves

Canyon Valley, Langford Valley, Cronise Valley, Coyote Lake Valley, Kane Wash Area, Iron Ridge Area, Lucerne Valley, and Johnson Valley GWBs (California Department of Water Resources 2010). The Mojave Basin Judgment allocated groundwater withdrawals in the area and required groundwater users that withdraw more than the allocated amount to purchase replenishment SWP water from the Watermaster or from another entity within the judgment. The judgment considers local surface water sources, including groundwater recharge near Hesperia with treated wastewater effluent from Lake Arrowhead Community Services District (California Department of Water Resources 2010). The judgment also provides for carryover storage between water years. The Mojave Water Agency has been appointed as the Watermaster.

The Warren Valley GWB was adjudicated in 1977 (California Department of Water Resources 2010). Hi-Desert Water District was appointed as the Watermaster to manage groundwater withdrawals and groundwater quality; provide SWP water, captured stormwater, and recycled water; and encourage conservation.

In 1991, the Bighorn-Desert Water Agency and Hi-Desert Water District agreed to the court-approved Ames Valley Basin Water Management Agreement. In accordance with this agreement, Hi-Desert Water District implemented the mainstream wells and expansion to conveyance and monitoring approaches.

I.2 Evaluation of Alternatives

This section describes the technical background for the evaluation of environmental consequences associated with the action alternatives and the No Action Alternative.

I.2.1 Methods and Tools

The impact assessment considers changes to groundwater related to changes in CVP and SWP operations under the alternatives compared to the No Action Alternative. This section details methods and tools used to evaluate those effects. Alternative 2 consists of four phases that could be utilized under its implementation. All four phases are considered in the assessment of Alternative 2 to bracket the range of potential impacts.

While the changes in CVP and SWP operations under the alternatives compared with the No Action Alternative do not directly result in pumping more or less groundwater, changes to CVP and SWP operations may change the amount of surface water delivered to users. A change in surface water deliveries may result in users changing their amount of groundwater pumping to offset this change in surface water supply. For example, if less surface water is supplied to an agricultural area, additional groundwater would need to be pumped and supplied to maintain cropping. The surface water supply analysis was conducted using CalSim 3, as described in Appendix F, *Model Documentation*, to simulate the operational assumptions of each alternative. The CalSim 3 results were then applied to the California Central Valley Groundwater-Surface Water Simulation Model – Fine Grid (C2VSimFG) groundwater flow model (see Appendix F) to simulate changes in groundwater conditions, including the changes to pumping, groundwater-surface water interaction, and groundwater elevation. The C2VSimFG modeling was conducted for the basins and GWSBs in the Sacramento and San Joaquin Valleys. A qualitative assessment was conducted in the other project areas.

The effects of the 2014 SGMA legislation were not explicitly simulated as part of the action alternatives. SGMA requires Groundwater basins be established and plans submitted for review by DWR for medium and high priority basins between January 31, 2020, and January 31, 2022. Critically over drafted basins, as defined by DWR, must be sustainably managed through GSPs within 20 years of those GSPs being adopted. Basins designated as low or very-low priority are not subject to SGMA. Adjudicated basins are not required to develop a GSP. Given the fact that GSPs for areas in the Central Valley have not been fully developed and adopted yet, the exact details of sustainable management under SGMA for each basin and GWSB are not known. However, there are six identified effects caused by groundwater conditions that are to be sustainably managed under a GSP: (1) chronic lowering of groundwater levels; (2) reduction in groundwater storage; (3) seawater intrusion; (4) degraded water quality; (5) land subsidence; and (6) depletion of interconnected surface water. For the development of the GSP, the Groundwater Sustainability Agency is required to manage the basin sustainably according to these criteria. Operation of the selected alternative will need to be incorporated in the development and implementation of the GSP.

DWR has designated each GWB and GWSB in the state with a low, medium, or high priority designation. Some GWBs have been designated with an additional "with overdraft" indication to designate that they are on a faster track towards management through a GSP. The development of a GSP may result in limitation of on groundwater pumping to limit decreases in groundwater levels. The C2VSimFG model does not directly simulate limitations to groundwater levels and pumping that may be imposed as part of SGMA. The model assumes that groundwater will be used to supplement water supply if surface water supplies are decreased to meet demands. Conversely, if surface water supplies are increased, the C2VSimFG model will decrease groundwater pumping. The model, therefore, may over predict increases in groundwater pumping, decreases in groundwater levels, increases in loss of surface water to groundwater, and subsidence. If groundwater supply is unable to be increased beyond a certain level (based on the GSP for the area) then the current demand level may not be able to be supported. Groundwater basins that are noted to have a higher priority per DWR or are denoted to be in overdraft conditions will likely have more limitations on groundwater pumping per SGMA.

Table I-1 shows the names of the alternatives used in the text, figures, and tables in this appendix.

Table I-1. Naming Conventions for Alternatives

Modeling Name	Figure/Table Name	Narrative Name
Alt1	Alt1	Alternative 1
Alt2v1 wTUCP	Alt2wTUCPwoVA	Alternative 2 With TUCP Without VA
Alt2v1	Alt2woTUCPwoVA	Alternative 2 Without TUCP Without VA
Alt2v2	Alt2woTUCPDeltaVA	Alternative 2 Without TUCP Delta VA
Alt2v3	Alt2woTUCPAllVA	Alternative 2 Without TUCP Systemwide VA
Alt3	Alt3	Alternative 3
Alt4	Alt4	Alternative 4

The results of the evaluation of the potential effects of the alternatives on groundwater resources has been organized into three regions, differing from other resources. Groundwater flow is dependent on the hydrologic boundaries of GWBs and GWSBs rather than political boundaries such as counties. Therefore, the results presented in this section are presented for the Trinity region, Central Valley, and Southern California.

I.2.2 No Action Alternative

Under the No Action Alternative, Reclamation would continue with current operation of the CVP, as described in the 2020 Record of Decision and subject to the 2019 Biological Opinions. The 2020 Record of Decision for the CVP and the 2020 Incidental Take Permit for the SWP represent current management direction or intensity pursuant to 43 CFR § 46.30.

The No Action Alternative is based on 2040 conditions. Changes that would occur over that time frame without implementation of the action alternatives are not analyzed in this technical appendix. However, the changes to groundwater resources that are assumed to occur by 2040 under the No Action Alternative are summarized in this section.

Conditions in 2040 would be different than existing conditions because of the following factors:

- Climate change and sea-level rise
- General plan development throughout California, including increased water demands in portions of the Sacramento Valley

By the end of September, the surface water elevations at CVP reservoirs generally decline, and the wetted area of reservoirs generally decreases, reducing the amount of surface water that can infiltrate to groundwater. It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2040 than in recent historical conditions, potentially resulting in changes to the amount of interaction flow between surface water and groundwater. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage.

Under the No Action Alternative, land uses in 2040 would occur in accordance with adopted general plans. Development under the general plans could affect groundwater resources, depending on the type and location of development. Infill projects where areas are already developed could increase density but would be done in compliance with applicable zoning and general plan policies around groundwater resources related to groundwater pumping and groundwater elevations. Development in non-urbanized areas could convert natural or rural areas to developed areas, resulting in similar impacts to groundwater resources.

The No Action Alternative would also rely upon increased use of Livingston-Stone National Fish Hatchery during droughts to increase production of winter-run Chinook salmon. However, this component requires no physical changes to the facility nor operational changes to groundwater.

I.2.3 Alternative 1

I.2.3.1 Potential Changes in Groundwater Pumping

Trinity River

Operations in the Trinity River would remain similar to those under the No Action Alternative. The Trinity River Restoration Program Record of Decision controls Trinity River operations, and Reclamation would continue to release flows into the Trinity River as it does under the No Action Alternative.

Central Valley

Compared to the No Action Alternative, Alternative 1 would cause flow changes in the Sacramento River from changes to coldwater pool management and changes in Delta fall outflow requirements. Flow changes could affect surface water available for use by SWP and CVP contractors. Alternative 1 is expected to cause a change in the amount of surface water delivered to users in the Central Valley. This change in surface water supply will result in changes to groundwater pumping. Groundwater pumping is primarily expected to change as a result of changes in agricultural pumping.

Groundwater pumping locations and amounts are typically not available, particularly pumping for agricultural uses. Because pumping rates are not available to be specified as input to the groundwater model, it is common practice for groundwater models of the region to calculate the amount of pumping. The calculated groundwater pumping is a function of the available water from the surface (e.g., rainfall, surface water deliveries) and the demand of the surface land use (e.g., crop type). Table I-2 shows annual groundwater pumping simulated by the C2VSimFG groundwater model across the entire Central Valley, from Red Bluff through the Tule region, including the Sacramento and San Joaquin valleys. Table I-2 also includes simulated groundwater pumping for the No Action Alternative and the other action alternatives, which will be described in later sections. Groundwater pumping results for each of the C2VSim subregions is provided in Attachment I-1. As noted in Section I.2.1, *Methods and Tools*, the C2VSimFG model does not simulate limitations to groundwater pumping that may be imposed as part of a local GSP. Therefore, the simulated groundwater pumping values simulated by C2VSimFG may overestimate the amount of groundwater pumping in certain areas.

Table I-2. Simulated Groundwater Pumping in the Central Valley

Year	WY Type (Sacramento Valley, San Joaquin Valley)	NAA (TAF)	Alt1 (TAF)	Alt 2v1 (TAF)	Alt2v1 wTUCP (TAF)	Alt 2v2 (TAF)	Alt 2v3 (TAF)	Alt 3 (TAF)	Alt 4 (TAF)
1	W, W	11,480	11,398	11,476	11,476	11,484	11,491	12,089	11,471
2	W, W	11,974	11,742	11,929	11,929	11,998	12,010	12,742	11,795
3	C, C	15,993	15,914	16,052	16,052	16,051	16,049	16,392	15,971
4	C, C	18,361	18,242	18,365	18,459	18,371	18,378	19,281	18,406
5	AN, W	12,115	12,128	12,114	12,110	12,192	12,208	12,832	12,095

Year	WY Type (Sacramento Valley, San Joaquin Valley)	NAA (TAF)	Alt1 (TAF)	Alt 2v1 (TAF)	Alt2v1 wTUCP (TAF)	Alt 2v2 (TAF)	Alt 2v3 (TAF)	Alt 3 (TAF)	Alt 4 (TAF)
6	BN, AN	11,948	11,707	11,969	11,945	11,996	12,050	12,478	11,757
7	AN, W	11,024	10,972	11,017	11,011	11,101	11,121	11,588	10,963
8	D, D	13,572	13,266	13,587	13,587	13,650	13,686	14,395	13,554
9	W, W	10,224	10,141	10,232	10,233	10,238	10,245	10,931	10,229
10	W, W	9,317	9,316	9,315	9,317	9,312	9,313	9,810	9,316
11	W, AN	12,217	12,185	12,200	12,201	12,208	12,209	12,838	12,190
12	D, D	13,560	13,446	13,595	13,596	13,645	13,657	14,231	13,556
13	W, W	11,172	11,146	11,197	11,198	11,193	11,194	11,864	11,163
14	D, D	14,141	13,979	14,207	14,206	14,240	14,262	14,684	14,114
15	C, C	15,521	15,323	15,721	15,723	15,630	15,735	16,186	15,702
16	D, C	15,738	15,582	15,777	15,776	15,813	15,801	16,252	15,766
17	C, C	16,066	15,846	16,021	16,069	15,930	16,014	16,278	16,037
18	C, C	16,285	16,182	16,361	16,384	16,342	16,381	16,516	16,340
19	C, C	16,907	16,791	16,923	16,922	16,813	16,865	16,981	16,875
20	AN, W	11,852	11,612	11,681	11,670	11,775	11,774	12,553	11,649
21	C, C	14,650	14,403	14,864	14,847	14,807	14,876	15,351	14,625
22	W, W	10,618	10,574	10,669	10,665	10,660	10,672	11,450	10,608
23	W, W	11,582	11,550	11,581	11,580	11,581	11,584	12,407	11,562
24	W, W	11,688	11,594	11,638	11,638	11,639	11,638	12,384	11,636
25	W, W	9,077	9,085	9,080	9,079	9,085	9,085	9,737	9,084
26	W, AN	11,117	11,077	11,109	11,109	11,112	11,118	11,821	11,094
27	AN, AN	12,334	12,036	12,300	12,299	12,418	12,432	13,116	12,119
28	D, D	14,164	13,856	14,211	14,209	14,260	14,286	14,702	14,102
29	D, D	14,818	14,658	14,844	14,843	14,894	14,907	15,603	14,824
30	AN, BN	13,112	12,950	13,127	13,129	13,213	13,215	13,936	13,152
31	BN, D	14,433	14,090	14,439	14,449	14,529	14,556	15,142	14,422
32	AN, W	10,589	10,447	10,566	10,569	10,638	10,659	11,352	10,555
33	W, W	10,369	10,353	10,360	10,359	10,367	10,374	11,029	10,355
34	D, C	15,096	14,912	15,090	15,089	15,147	15,161	15,643	15,107
35	C, C	15,291	15,148	15,402	15,403	15,442	15,451	16,044	15,398
36	D, BN	15,777	15,638	15,807	15,802	15,858	15,867	16,169	15,818
37	BN, AN	12,847	12,748	12,873	12,874	12,927	12,936	13,366	12,817
38	W, W	10,067	10,036	10,068	10,068	10,062	10,067	10,714	10,051

Year	WY Type (Sacramento Valley, San Joaquin Valley)	NAA (TAF)	Alt1 (TAF)	Alt 2v1 (TAF)	Alt2v1 wTUCP (TAF)	Alt 2v2 (TAF)	Alt 2v3 (TAF)	Alt 3 (TAF)	Alt 4 (TAF)
39	BN, D	13,779	13,666	13,696	13,696	13,745	13,756	14,445	13,710
40	D, C	16,652	16,552	16,772	16,774	16,795	16,849	17,269	16,777
41	C, C	19,152	19,052	19,236	19,272	19,231	19,252	19,881	19,206
42	C, C	18,860	18,811	18,850	18,857	18,817	18,831	19,340	18,928
Average		**13,465**	**13,337**	**13,484**	**13,487**	**13,505**	**13,524**	**14,091**	**13,450**
Maximum		**19,152**	**19,052**	**19,236**	**19,272**	**19,231**	**19,252**	**19,881**	**19,206**
Minimum		**9,077**	**9,085**	**9,080**	**9,079**	**9,085**	**9,085**	**9,737**	**9,084**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Table I-3 shows the change in simulated groundwater pumping for Alternative 1 as compared to the No Action Alternative. Alternative 1 results in an average annual decrease in groundwater pumping of 128 thousand acre-feet (TAF), with a maximum single year increase in groundwater pumping of 13 TAF and an maximum single year decrease in groundwater pumping of 343 TAF.

Table I-3. Simulated Change in Groundwater Pumping in the Central Valley for Alternative 1 Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt1 minus NAA (TAF)	Alt1 minus NAA (% Difference)
1	W, W	-82	-0.7%
2	W, W	-231	-1.9%
3	C, C	-78	-0.5%
4	C, C	-119	-0.6%
5	AN, W	13	0.1%
6	BN, AN	-240	-2.0%
7	AN, W	-53	-0.5%
8	D, D	-306	-2.3%
9	W, W	-83	-0.8%
10	W, W	-1	0.0%
11	W, AN	-32	-0.3%
12	D, D	-114	-0.8%
13	W, W	-26	-0.2%
14	D, D	-162	-1.1%
15	C, C	-198	-1.3%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt1 minus NAA (TAF)	Alt1 minus NAA (% Difference)
16	D, C	-156	-1.0%
17	C, C	-220	-1.4%
18	C, C	-104	-0.6%
19	C, C	-116	-0.7%
20	AN, W	-240	-2.0%
21	C, C	-247	-1.7%
22	W, W	-45	-0.4%
23	W, W	-32	-0.3%
24	W, W	-95	-0.8%
25	W, W	8	0.1%
26	W, AN	-40	-0.4%
27	AN, AN	-298	-2.4%
28	D, D	-308	-2.2%
29	D, D	-160	-1.1%
30	AN, BN	-162	-1.2%
31	BN, D	-343	-2.4%
32	AN, W	-142	-1.3%
33	W, W	-16	-0.2%
34	D, C	-184	-1.2%
35	C, C	-142	-0.9%
36	D, BN	-138	-0.9%
37	BN, AN	-99	-0.8%
38	W, W	-31	-0.3%
39	BN, D	-113	-0.8%
40	D, C	-100	-0.6%
41	C, C	-100	-0.5%
42	C, C	-48	-0.3%
Average		**-128**	**-0.9%**
Maximum		**13**	**0.1%**
Minimum		**-343**	**-2.4%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Central Coast Region

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H, *Water Supply Technical Appendix*, provides an analysis of potential changes in surface water supply delivered by each of the alternatives. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP.

The groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water originally sourced by surface deliveries. Surface deliveries from the SWP are also in some Central Coast basins, an important support for satisfying salinity standards. In these basins, existing salinity levels in the underlying groundwater would limit its use to replace reduced surface water deliveries needed to support both sources of recharge. Without the ongoing support of groundwater recharge in this region, groundwater levels may decrease, eventually resulting in reduced groundwater production.

Southern California Region

Similar to the Central Coast Region, the C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Southern California Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP.

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I.2.3.2 Potential Changes in Groundwater-Surface Water Interaction Flow

Trinity River

Most usable groundwater in the Trinity River Region occurs in widely scattered alluvium-filled valleys, such as those immediately adjacent to the Trinity River. These valleys contain only small quantities of recoverable groundwater and therefore are not considered a major source. Given this hydrogeologic nature of this region, changes in surface water flow will likely result in little change to the groundwater-surface water interaction flow.

Central Valley

Table I-4 shows annual groundwater pumping simulated by the C2VSimFG groundwater model across the entire Central Valley, from Red Bluff through the Tule region, including the Sacramento and San Joaquin valleys. Table I-2 also includes simulated groundwater pumping for the No Action Alternative and the other action alternatives, which will be described in later sections. Additional groundwater-surface water interaction flow results for each of the C2VSim subregions is provided in Attachment I-1.

Table I-4. Simulated Groundwater-Surface Water Interaction Flow in the Central Valley

Year	WY Type (Sacramento Valley, San Joaquin Valley)	NAA (TAF)	Alt1 (TAF)	Alt2v1 (TAF)	Alt2v1 wTUCP (TAF)	Alt2v2 (TAF)	Alt2v3 (TAF)	Alt3 (TAF)	Alt4 (TAF)
1	W, W	152	34	157	156	171	206	420	119
2	W, W	-73	-155	-78	-79	-61	-30	195	-81
3	C, C	29	-30	27	25	47	78	401	12
4	C, C	822	708	864	855	886	905	1,453	820
5	AN, W	3,033	2,937	3,044	3,098	3,068	3,090	3,570	3,014
6	BN, AN	731	652	753	757	754	810	1,200	764
7	AN, W	1,069	947	1,077	1,076	1,114	1,160	1,373	1,006
8	D, D	158	36	158	158	187	237	593	116
9	W, W	539	441	561	562	579	625	922	521
10	W, W	-588	-699	-583	-582	-558	-539	-39	-600
11	W, AN	-1,716	-1,842	-1,732	-1,731	-1,711	-1,695	-1,388	-1,754
12	D, D	-1,057	-1,178	-1,050	-1,049	-1,013	-985	-651	-1,078
13	W, W	-497	-598	-478	-478	-478	-451	-76	-506
14	D, D	-672	-776	-662	-662	-642	-612	-186	-726
15	C, C	-120	-228	-123	-123	-120	-58	402	-150
16	D, C	668	558	721	721	739	776	1,226	672

Year	WY Type (Sacramento Valley, San Joaquin Valley)	NAA (TAF)	Alt1 (TAF)	Alt2v1 (TAF)	Alt2v1 wTUCP (TAF)	Alt2v2 (TAF)	Alt2v3 (TAF)	Alt3 (TAF)	Alt4 (TAF)
17	C, C	533	421	544	538	536	592	1,019	518
18	C, C	1,342	1,246	1,402	1,397	1,403	1,440	1,817	1,337
19	C, C	1,564	1,510	1,691	1,695	1,717	1,763	2,083	1,616
20	AN, W	1,932	1,817	1,957	1,946	1,947	1,973	2,176	1,899
21	C, C	996	917	998	1,002	1,019	1,065	1,392	979
22	W, W	2,140	2,000	2,186	2,188	2,184	2,220	2,548	2,107
23	W, W	840	685	860	859	860	890	1,250	806
24	W, W	572	442	580	579	586	610	1,063	531
25	W, W	107	-15	115	115	123	141	648	88
26	W, AN	-1,251	-1,391	-1,263	-1,263	-1,260	-1,242	-914	-1,302
27	AN, AN	-625	-740	-605	-606	-607	-575	-249	-628
28	D, D	-558	-676	-544	-546	-530	-485	-53	-595
29	D, D	-63	-191	-46	-47	-27	41	370	-65
30	AN, BN	281	140	280	280	269	318	672	218
31	BN, D	94	-39	94	94	106	172	483	55
32	AN, W	297	172	309	310	327	381	774	295
33	W, W	141	-46	140	139	170	212	701	95
34	D, C	-313	-447	-303	-303	-289	-256	95	-323
35	C, C	250	144	240	241	255	316	822	215
36	D, BN	655	556	684	684	716	758	1,159	655
37	BN, AN	1,135	1,031	1,160	1,159	1,163	1,194	1,457	1,135
38	W, W	872	677	874	874	910	950	1,467	830
39	BN, D	-96	-254	-100	-100	-76	-44	328	-129
40	D, C	383	279	397	397	437	478	833	371
41	C, C	937	836	998	981	989	1,025	1,594	933
42	C, C	1,468	1,375	1,542	1,563	1,547	1,571	2,277	1,524
Average		**384**	**268**	**401**	**402**	**415**	**453**	**839**	**365**
Maximum		**3,033**	**2,937**	**3,044**	**3,098**	**3,068**	**3,090**	**3,570**	**3,014**
Minimum		**-1,716**	**-1,842**	**-1,732**	**-1,731**	**-1,711**	**-1,695**	**-1,388**	**-1,754**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Table I-5 shows the change in simulated groundwater-surface water interaction flow for Alternative 1 as compared to the No Action Alternative. Alternative 1 results in an average annual decrease in flow from surface water to groundwater of 116 TAF, with a minimum single year increase in flow from groundwater to surface water of 54 TAF and an maximum single year decrease in flow from surface water to groundwater of 194 TAF.

Table I-5. Simulated Change in Groundwater-Surface Water Interaction Flow in the Central Valley for Alternative 1 Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt1 minus NAA (TAF)	Alt1 minus NAA (% Difference)
1	W, W	-118	-77.7%
2	W, W	-82	-112.5%
3	C, C	-59	-206.1%
4	C, C	-114	-13.9%
5	AN, W	-96	-3.2%
6	BN, AN	-79	-10.8%
7	AN, W	-123	-11.5%
8	D, D	-122	-77.2%
9	W, W	-98	-18.3%
10	W, W	-111	-18.9%
11	W, AN	-126	-7.4%
12	D, D	-122	-11.5%
13	W, W	-102	-20.5%
14	D, D	-104	-15.5%
15	C, C	-108	-90.1%
16	D, C	-111	-16.5%
17	C, C	-112	-21.0%
18	C, C	-96	-7.2%
19	C, C	-54	-3.5%
20	AN, W	-115	-5.9%
21	C, C	-80	-8.0%
22	W, W	-141	-6.6%
23	W, W	-154	-18.4%
24	W, W	-130	-22.7%
25	W, W	-122	-114.5%
26	W, AN	-140	-11.2%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt1 minus NAA (TAF)	Alt1 minus NAA (% Difference)
27	AN, AN	-115	-18.4%
28	D, D	-118	-21.2%
29	D, D	-128	-203.4%
30	AN, BN	-141	-50.2%
31	BN, D	-133	-141.8%
32	AN, W	-125	-42.0%
33	W, W	-187	-132.7%
34	D, C	-134	-42.7%
35	C, C	-106	-42.5%
36	D, BN	-100	-15.2%
37	BN, AN	-104	-9.2%
38	W, W	-194	-22.3%
39	BN, D	-159	-165.6%
40	D, C	-104	-27.2%
41	C, C	-102	-10.8%
42	C, C	-92	-6.3%
Average		**-116**	**-44.8%**
Maximum		**-54**	**-3.2%**
Minimum		**-194**	**-206.1%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Central Coast Region

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered by each of the alternatives. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

Southern California Region

Similar to the Central Coast Region, the C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Southern California Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

I.2.3.3 Potential Changes in Groundwater Elevation

Trinity River

Given that there is likely to be little change to the volume of groundwater either through pumping or groundwater-surface water interaction flow, there will be little change to groundwater levels in the area.

Central Valley

The C2VSimFG groundwater model provides simulated groundwater level over the entire model simulation period for every "node" in the model (nodes cover all subregions noted in Figure I-2). To provide a visualization of groundwater levels over time, the groundwater levels simulated by C2VSimFG were exported from the model at multiple locations throughout the model's domain. Figure I-2 shows the 92 selected locations. Figure I-3 through Figure I-94 show the simulated change in groundwater table elevation for each node with the implementation of Alternative 1 in comparison to the No Action Alternative. The figures also show the simulation results for the other alternatives discussed in subsequent sections.

The simulated change in groundwater table elevation for Alternative 1 as compared to the No Action Alternative spans a range from a decrease of 3.2 feet to an increase of 47.4 feet. However, note that this range of potential change captures the predicted groundwater table elevations across all 92 locations shown in the figures.

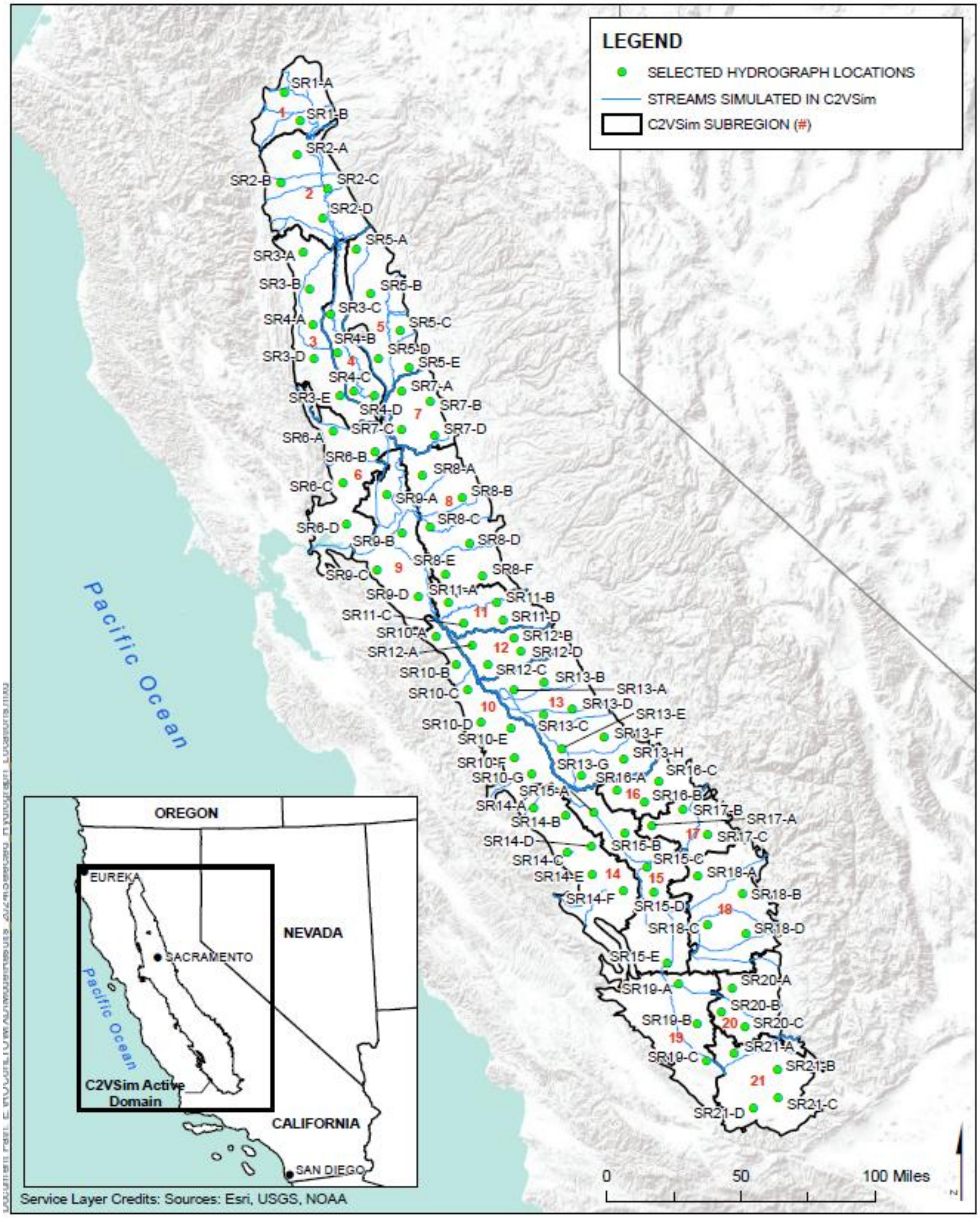


Figure I-2. Location Selected Hydrographs

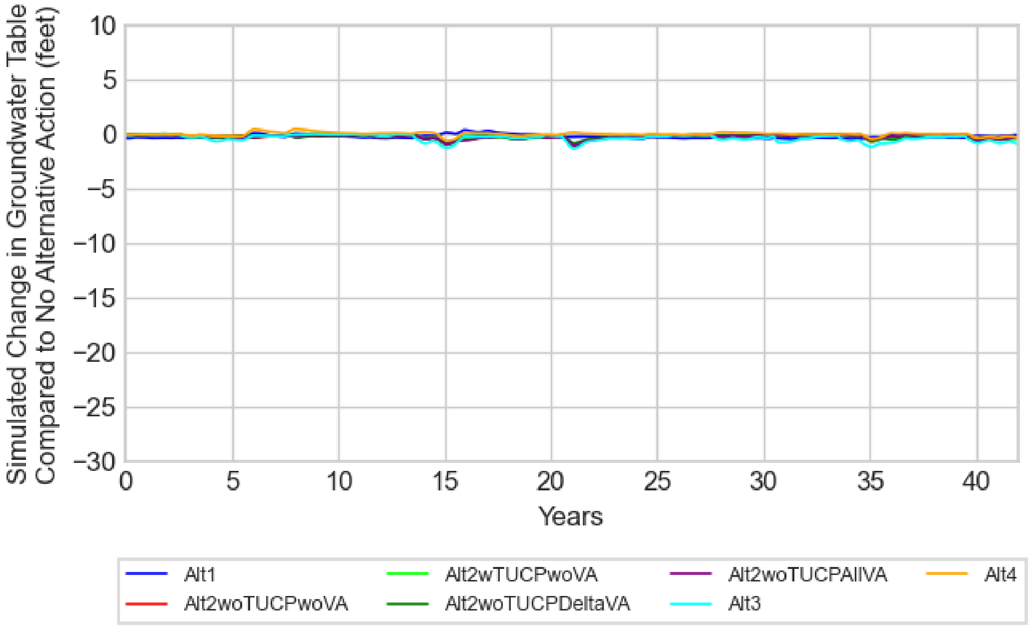


Figure I-3. Simulated Change in Groundwater Table Elevation at Location SR1-A

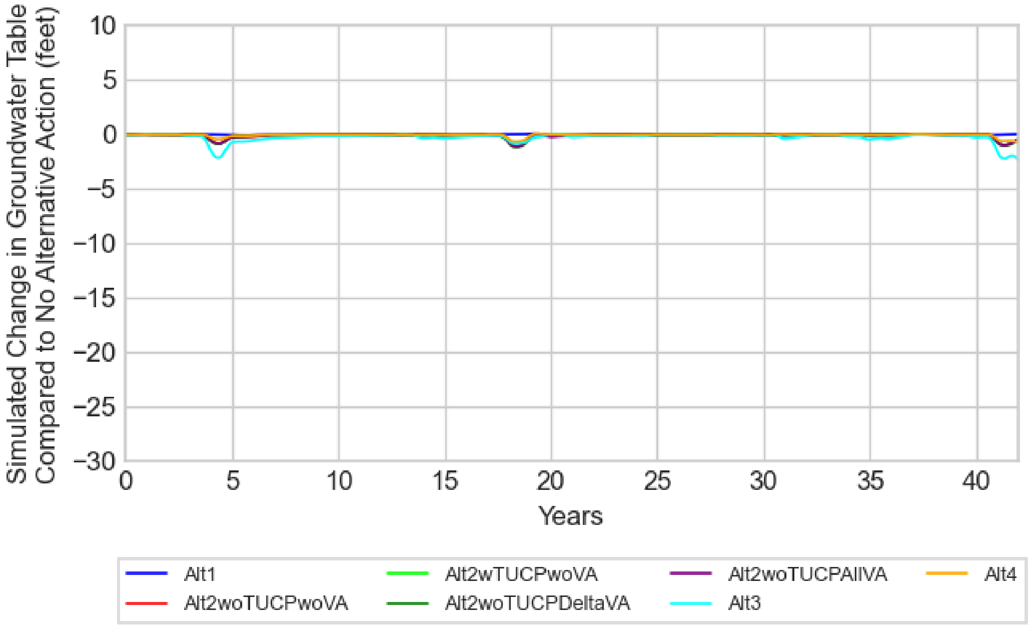


Figure I-4. Simulated Change in Groundwater Table Elevation at Location SR1-B

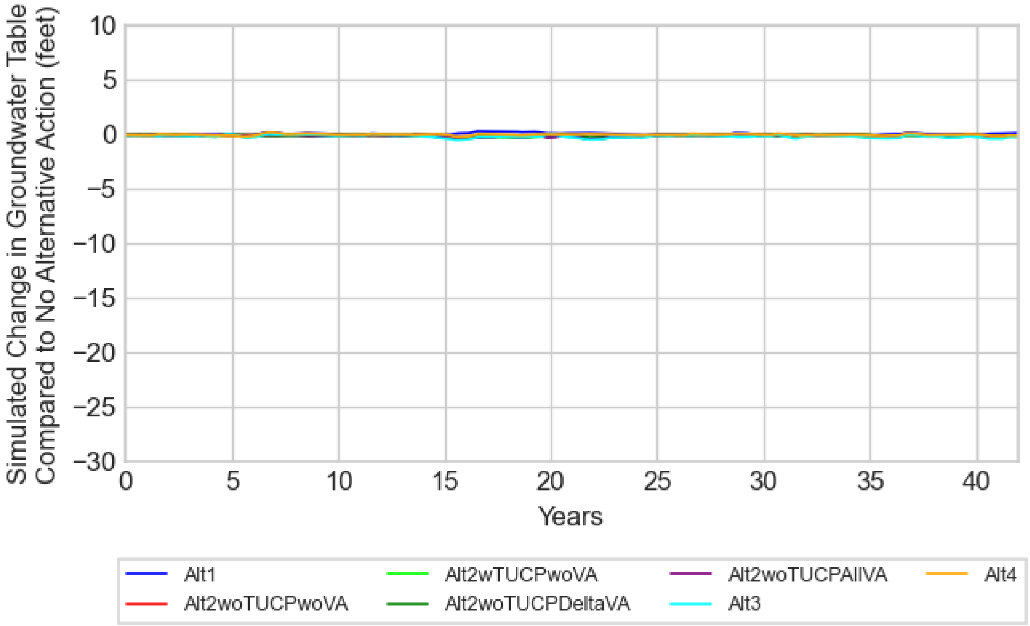


Figure I-5. Simulated Change in Groundwater Table Elevation at Location SR2-A

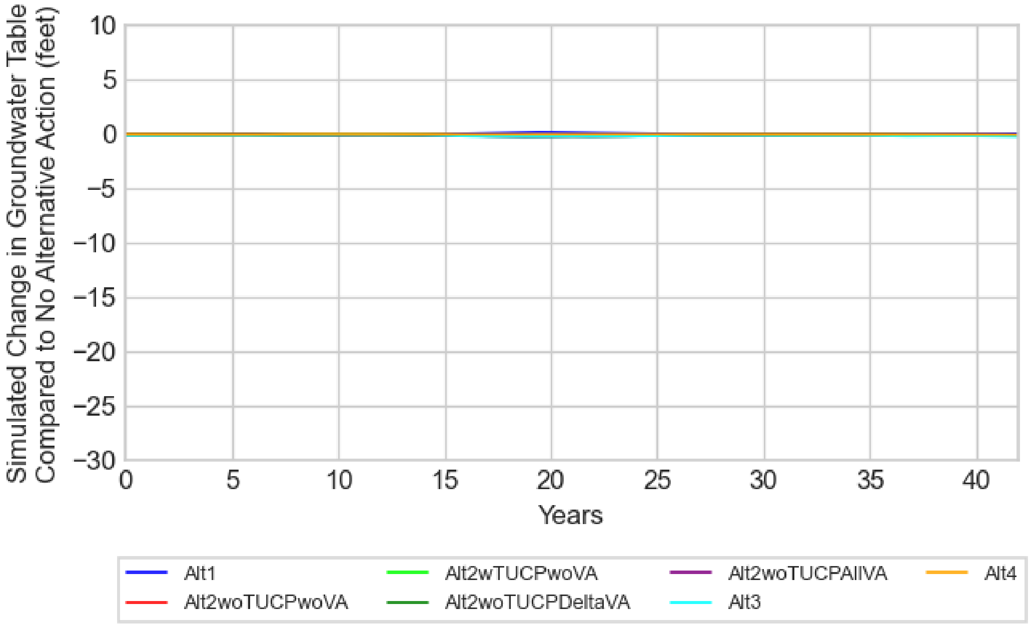


Figure I-6. Simulated Change in Groundwater Table Elevation at Location SR2-B

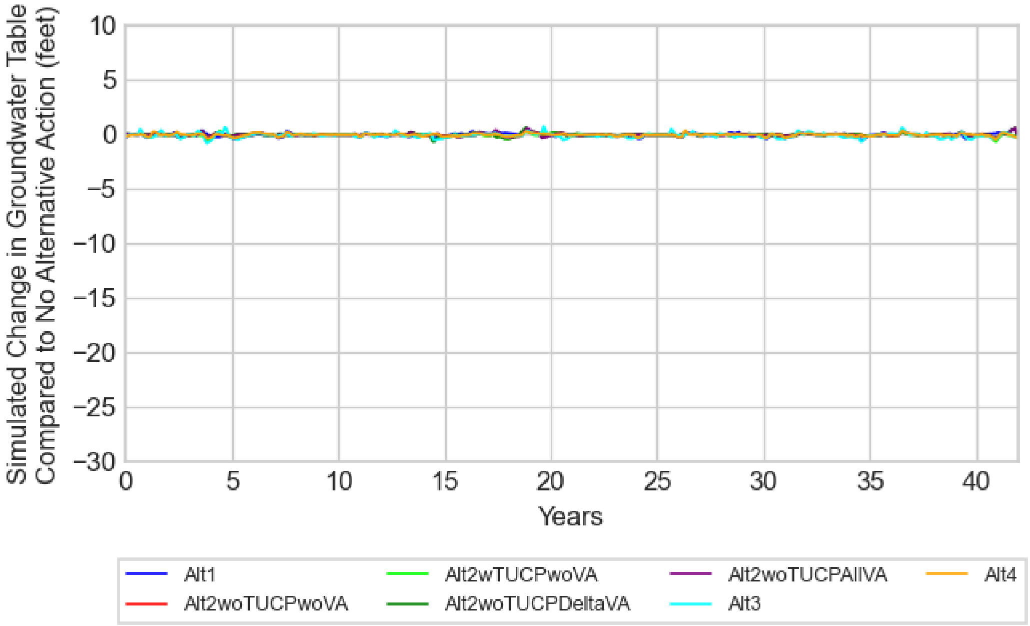


Figure I-7. Simulated Change in Groundwater Table Elevation at Location SR2-C

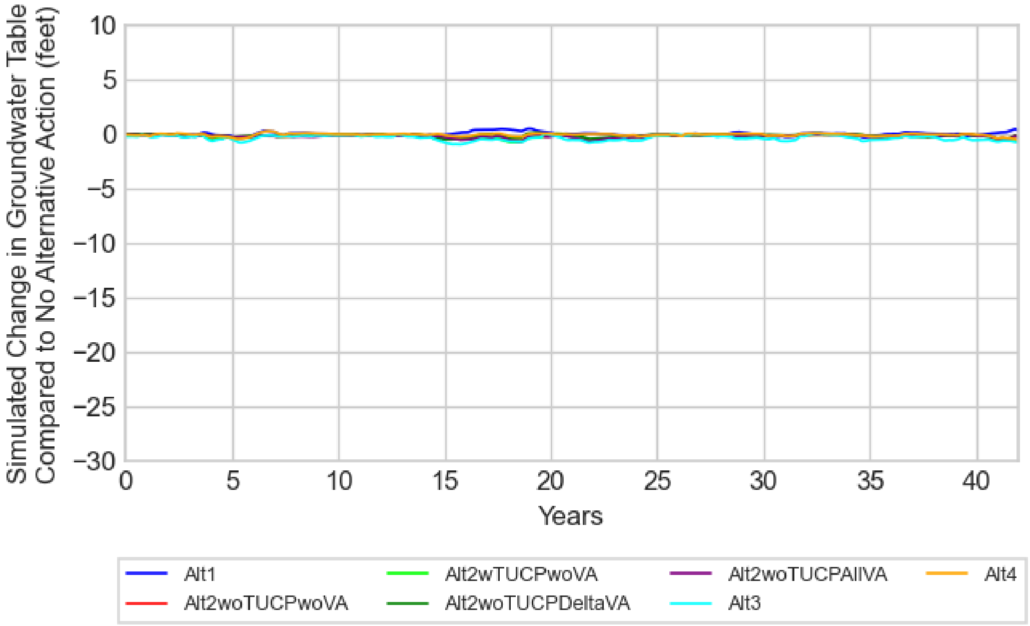


Figure I-8. Simulated Change in Groundwater Table Elevation at Location SR2-D

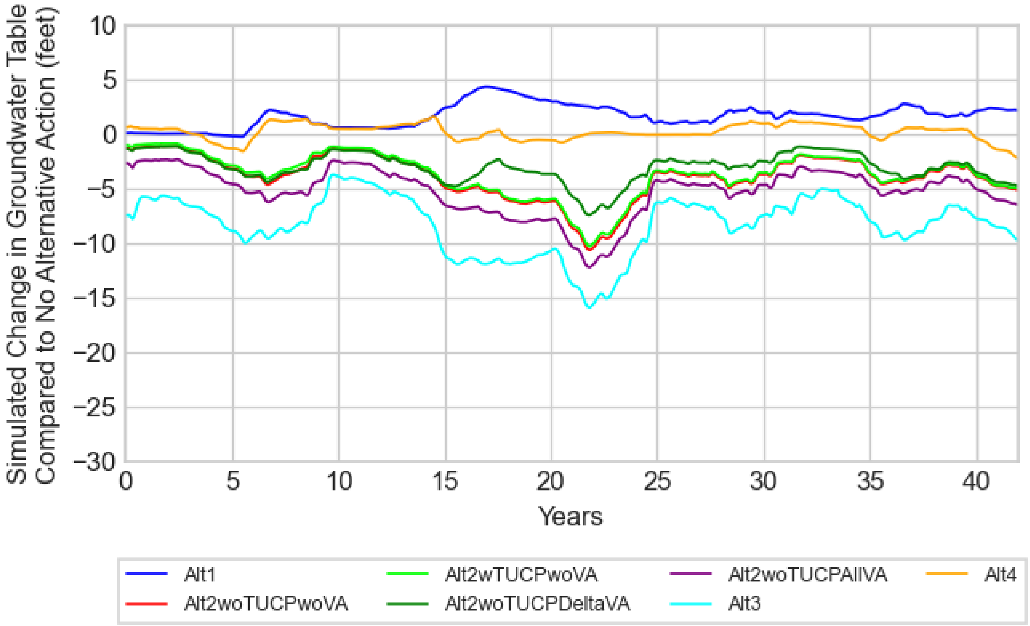


Figure I-9. Simulated Change in Groundwater Table Elevation at Location SR3-A

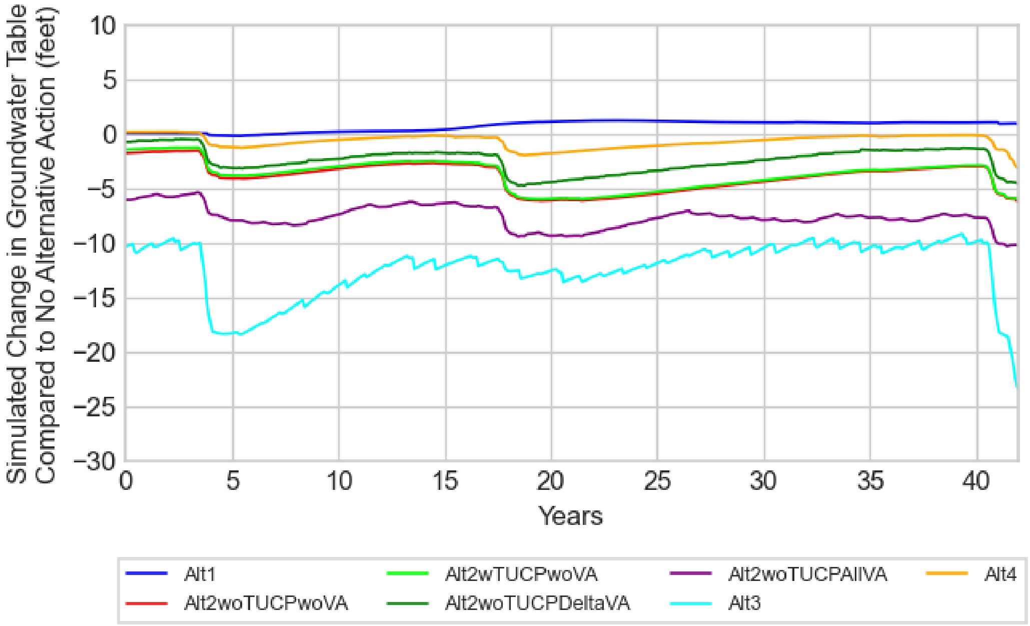


Figure I-10. Simulated Change in Groundwater Table Elevation at Location SR3-B

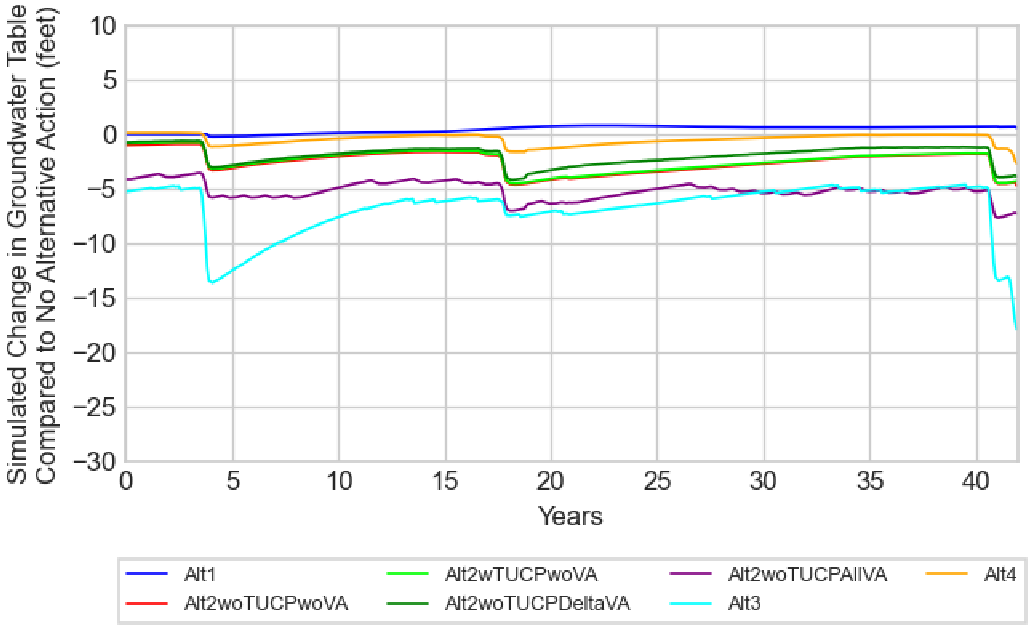


Figure I-11. Simulated Change in Groundwater Table Elevation at Location SR3-C

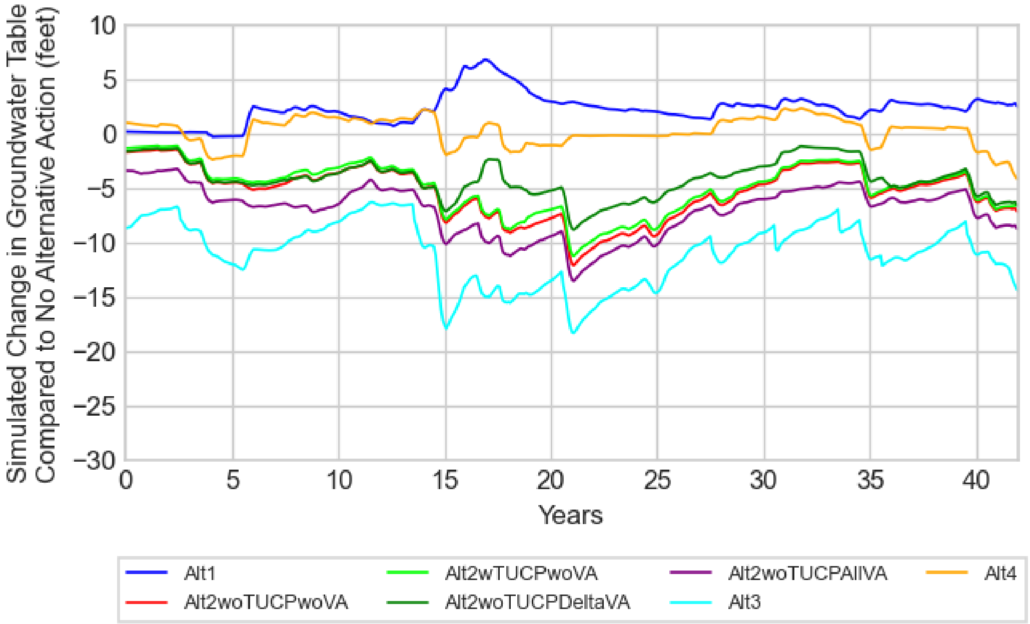


Figure I-12. Simulated Change in Groundwater Table Elevation at Location SR3-D

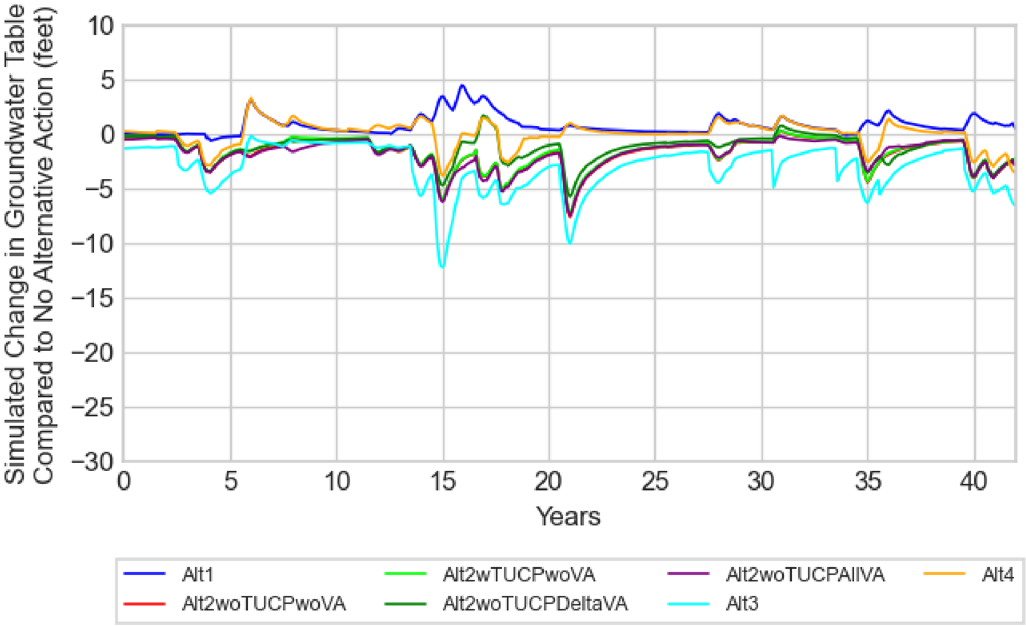


Figure I-13. Simulated Change in Groundwater Table Elevation at Location SR3-E

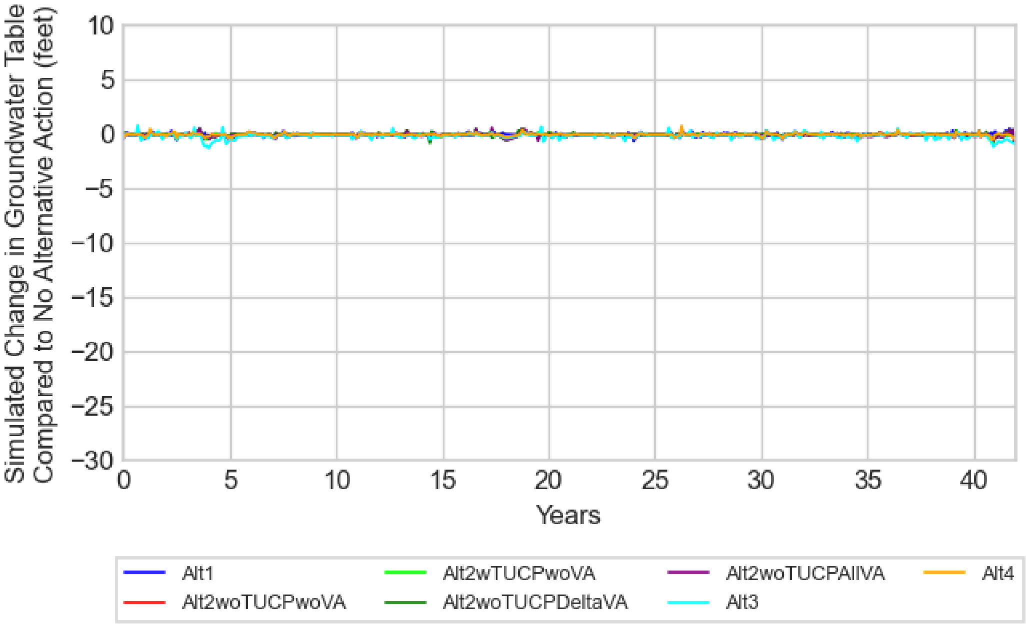


Figure I-14. Simulated Change in Groundwater Table Elevation at Location SR4-A

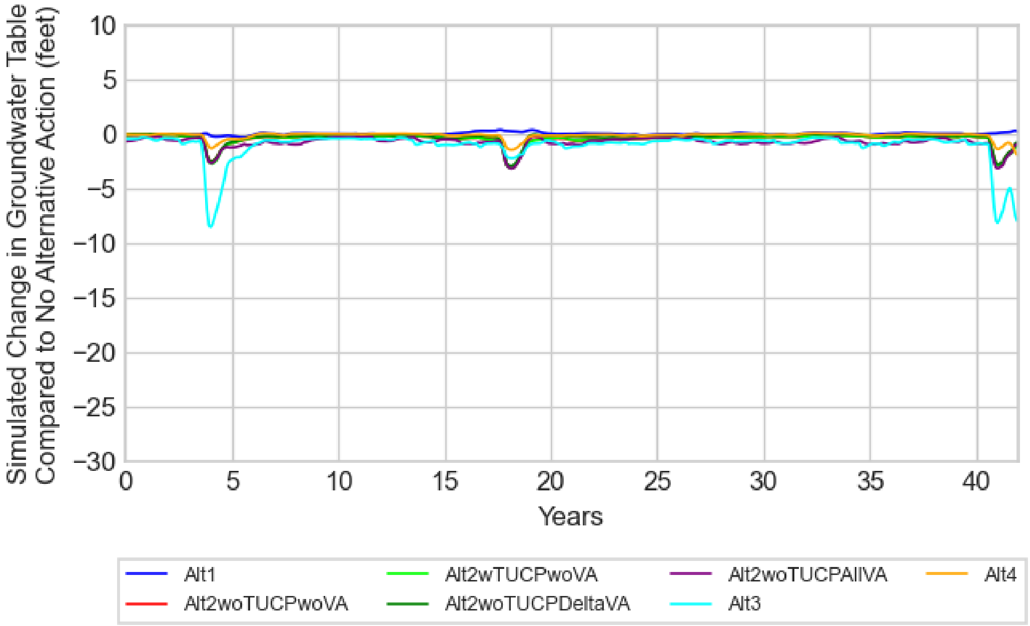


Figure I-15. Simulated Change in Groundwater Table Elevation at Location SR4-B

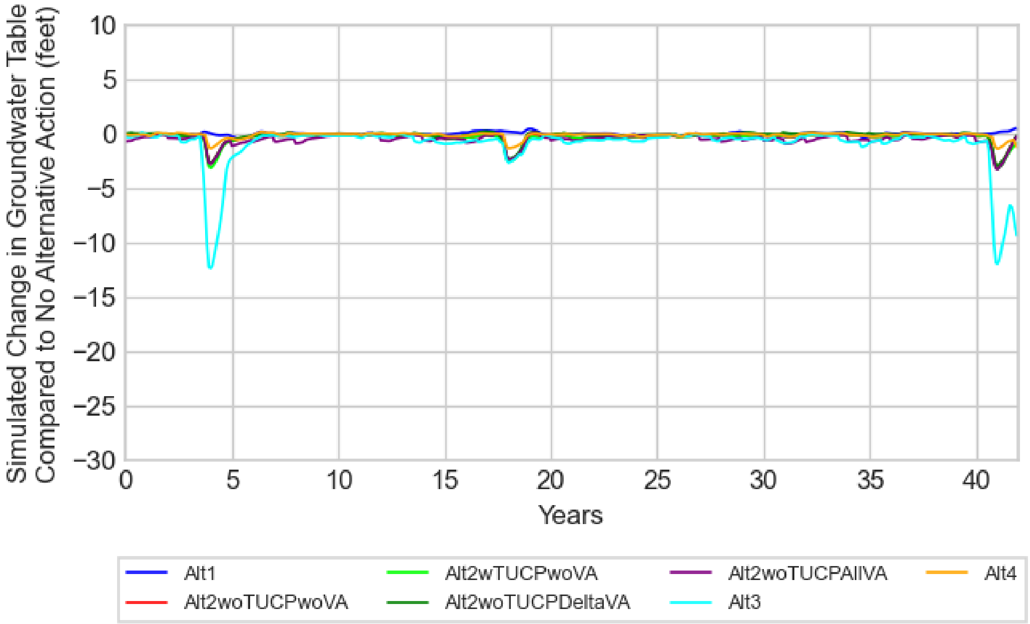


Figure I-16. Simulated Change in Groundwater Table Elevation at Location SR4-C

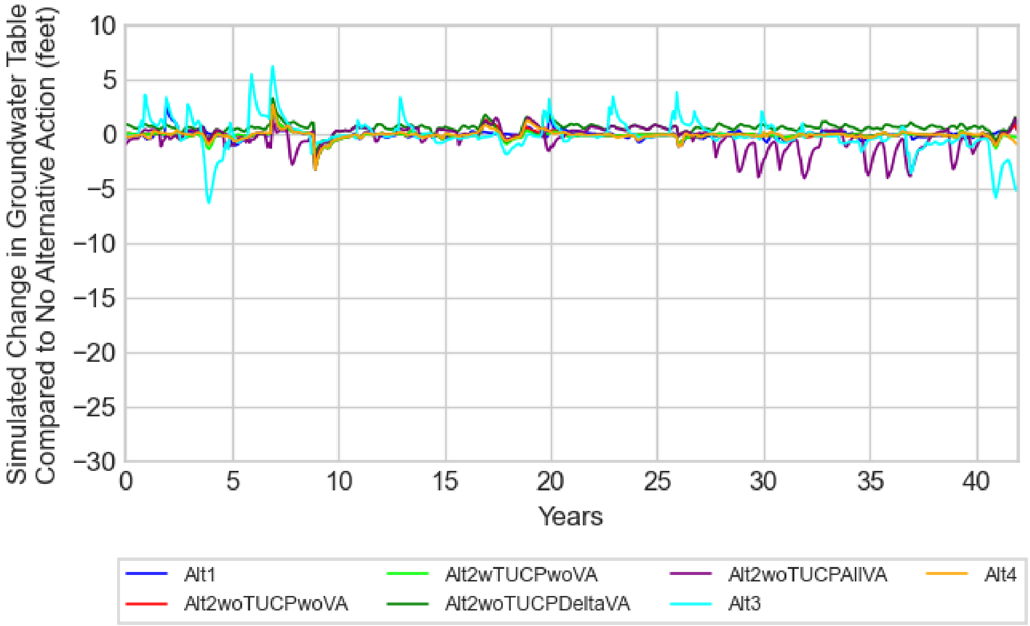


Figure I-17. Simulated Change in Groundwater Table Elevation at Location SR4-D

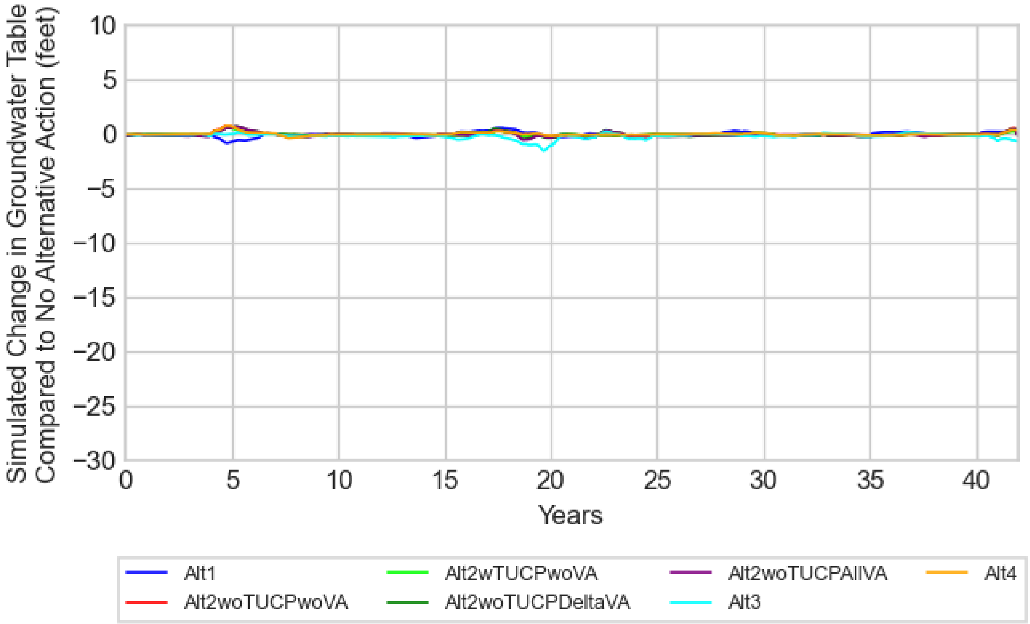


Figure I-18. Simulated Change in Groundwater Table Elevation at Location SR5-A

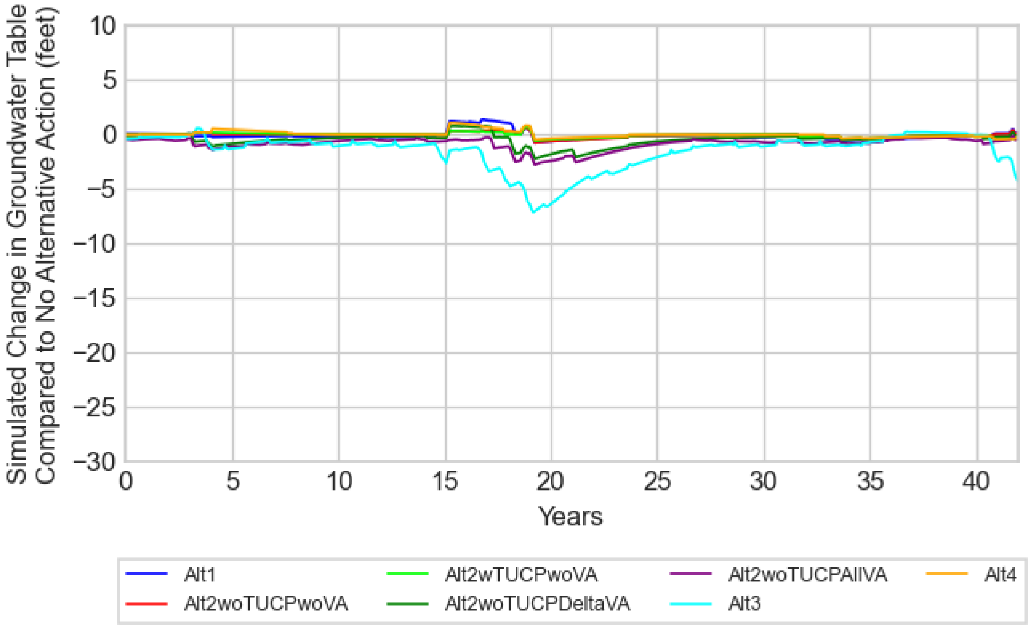


Figure I-19. Simulated Change in Groundwater Table Elevation at Location SR5-B

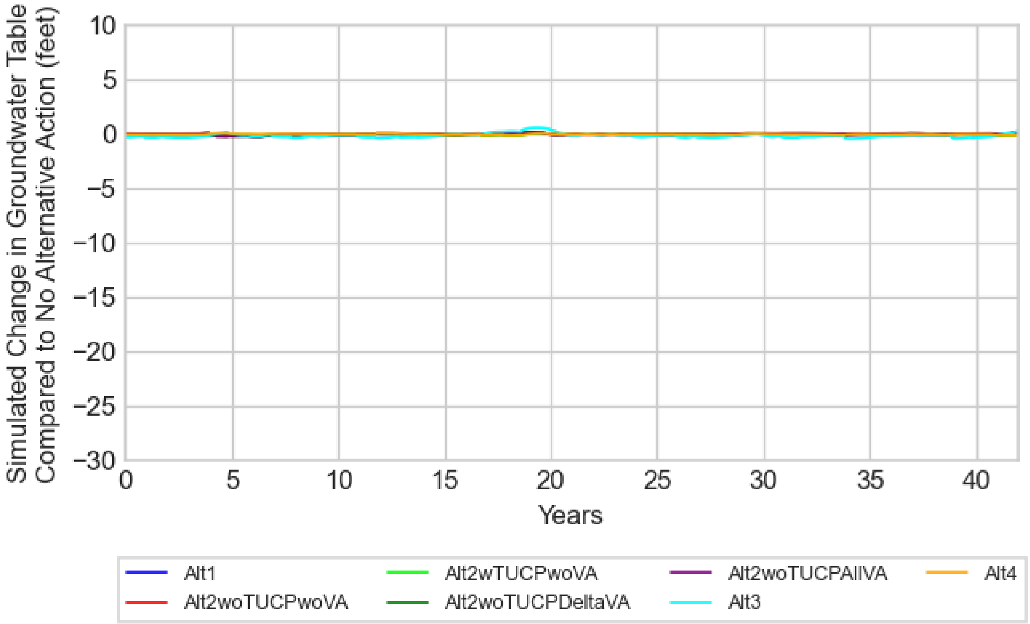


Figure I-20. Simulated Change in Groundwater Table Elevation at Location SR5-C

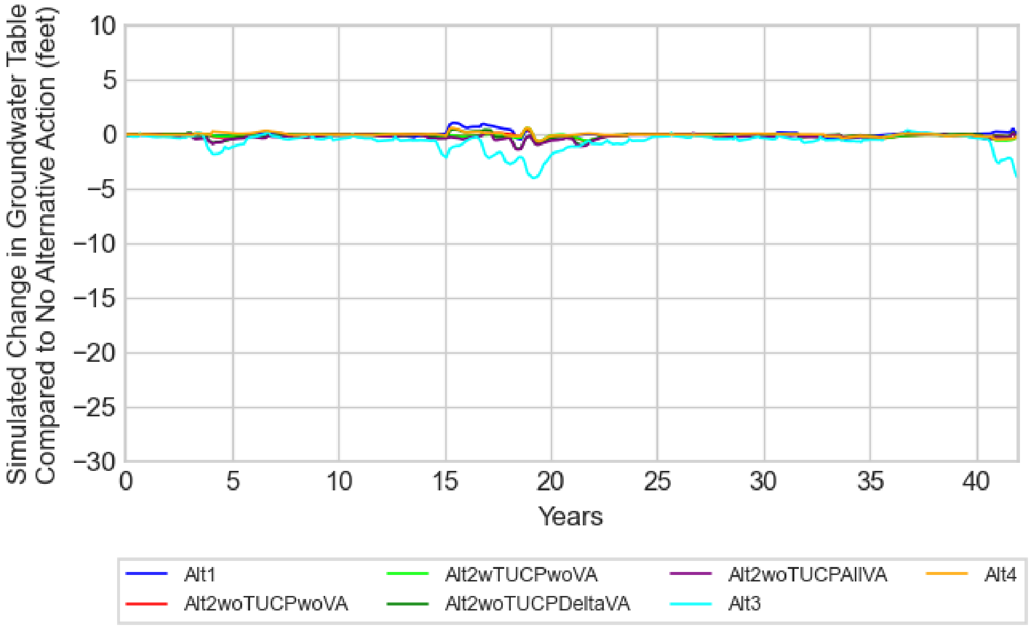


Figure I-21. Simulated Change in Groundwater Table Elevation at Location SR5-D

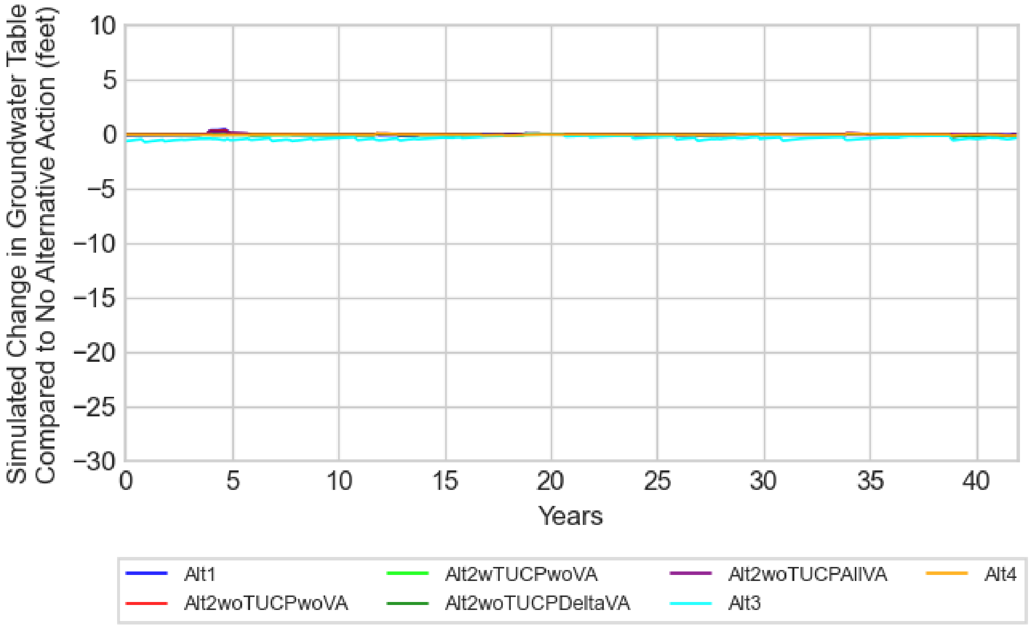


Figure I-22. Simulated Change in Groundwater Table Elevation at Location SR5-E

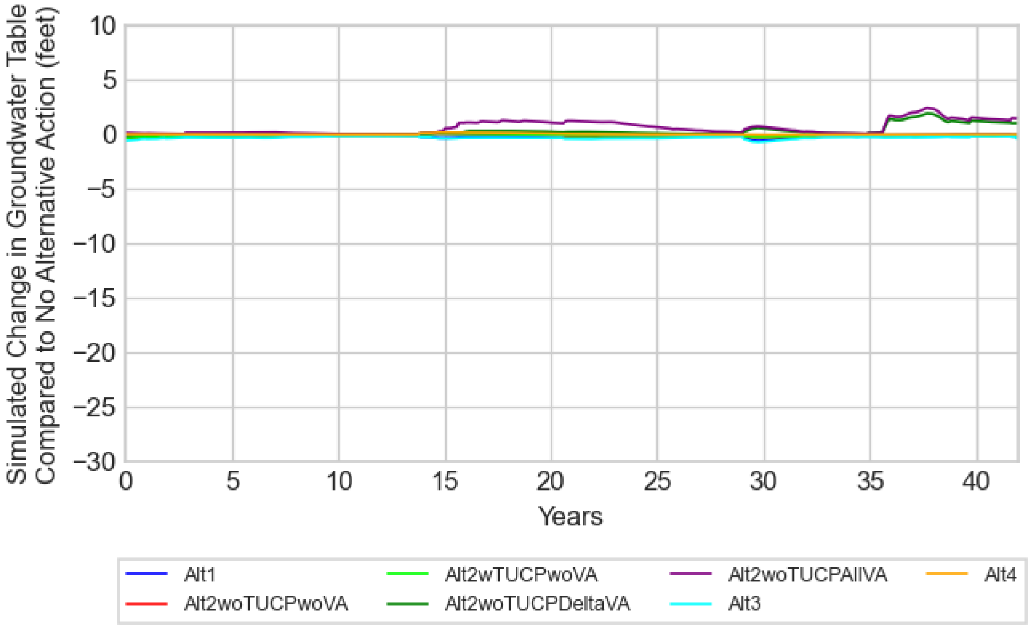


Figure I-23. Simulated Change in Groundwater Table Elevation at Location SR6-A

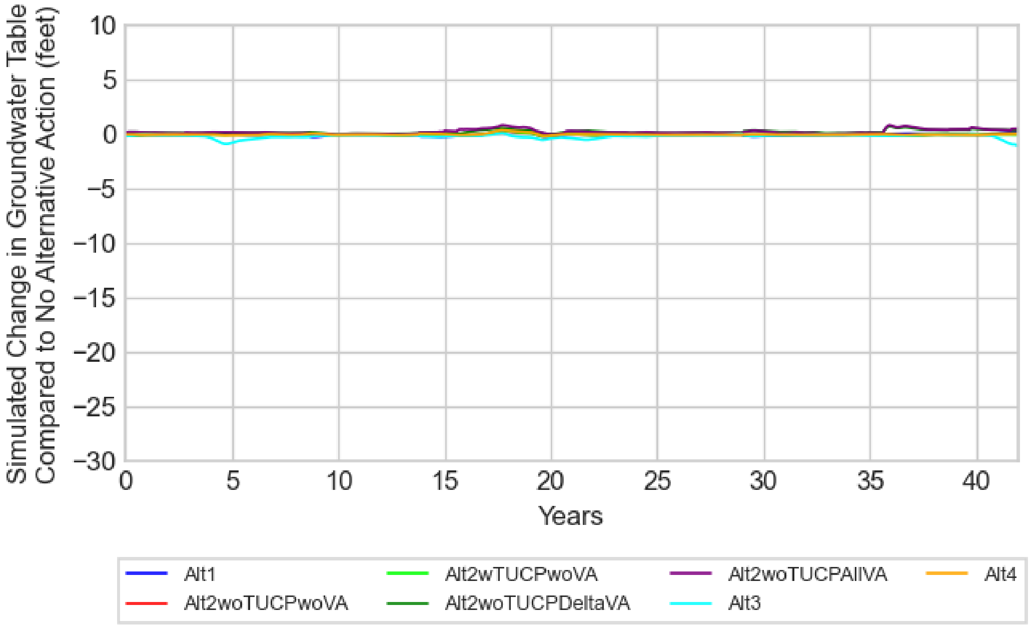


Figure I-24. Simulated Change in Groundwater Table Elevation at Location SR6-B

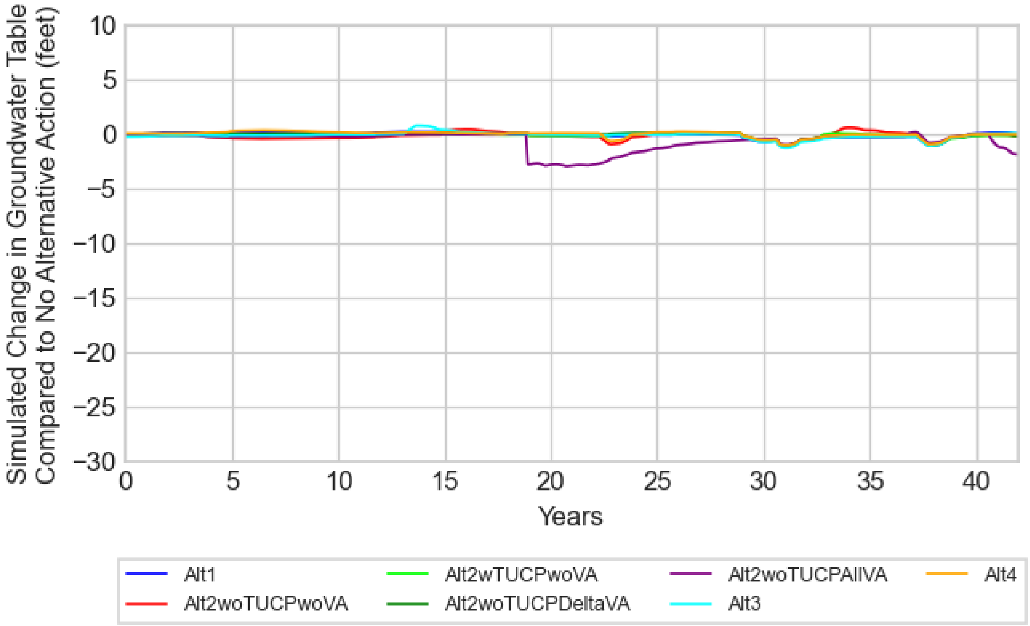


Figure I-25. Simulated Change in Groundwater Table Elevation at Location SR6-C

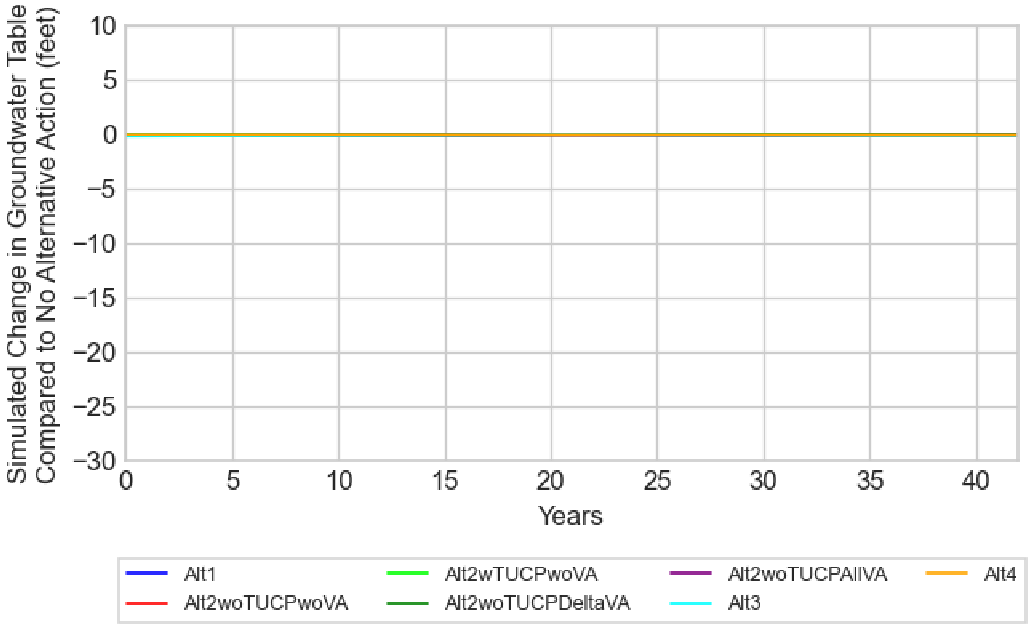


Figure I-26. Simulated Change in Groundwater Table Elevation at Location SR6-D

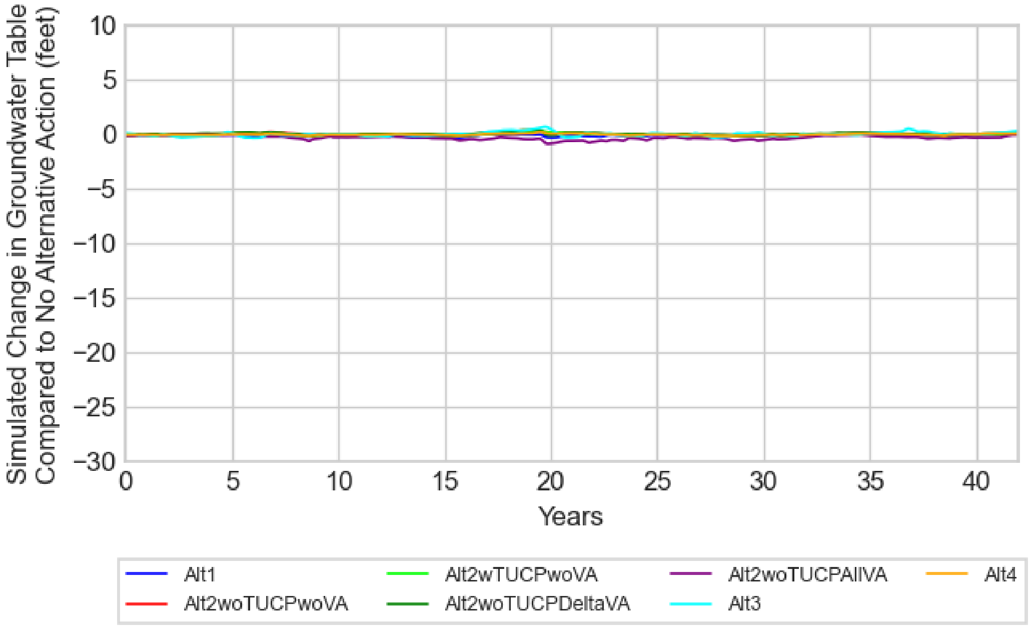


Figure I-27. Simulated Change in Groundwater Table Elevation at Location SR7-A

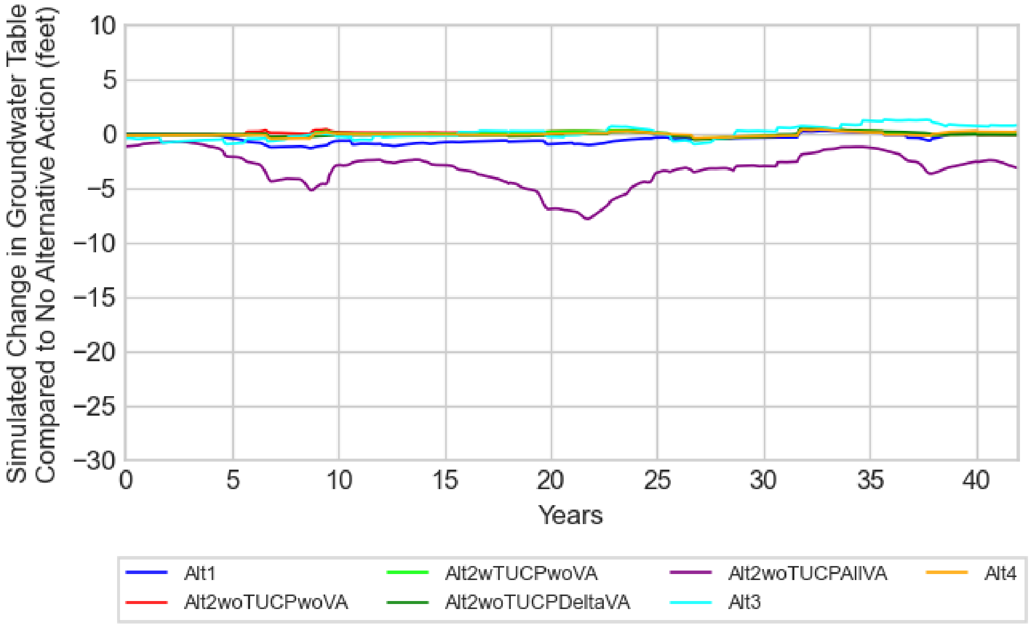


Figure I-28. Simulated Change in Groundwater Table Elevation at Location SR7-B

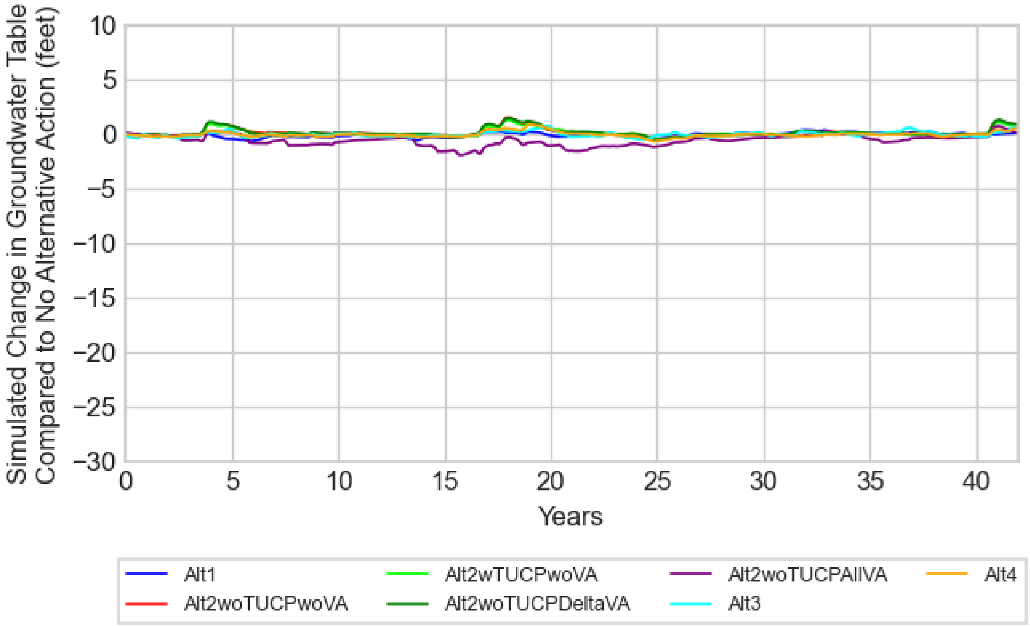


Figure I-29. Simulated Change in Groundwater Table Elevation at Location SR7-C

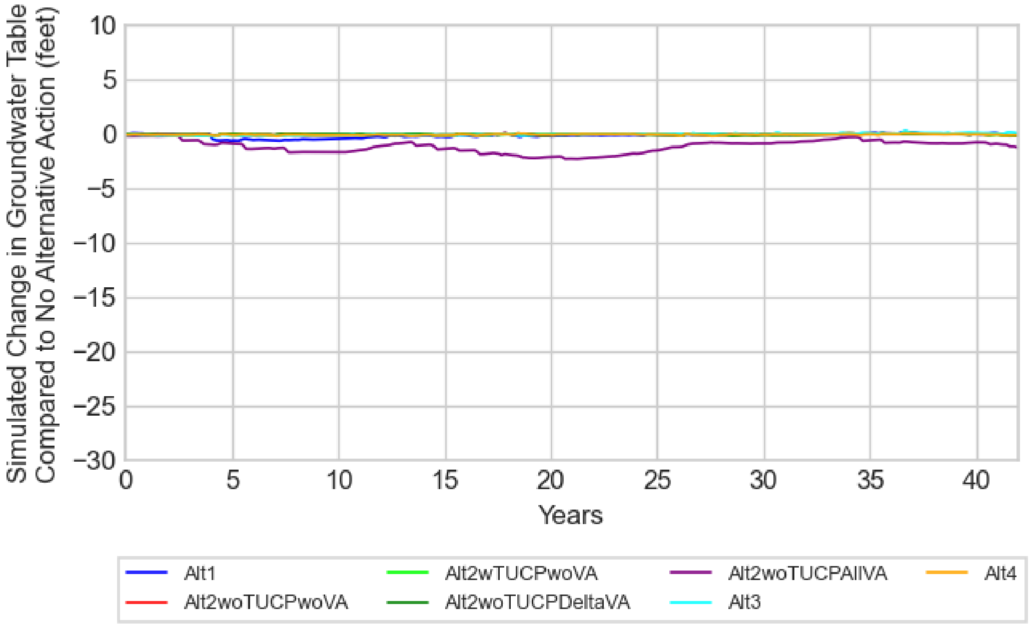


Figure I-30. Simulated Change in Groundwater Table Elevation at Location SR7-D

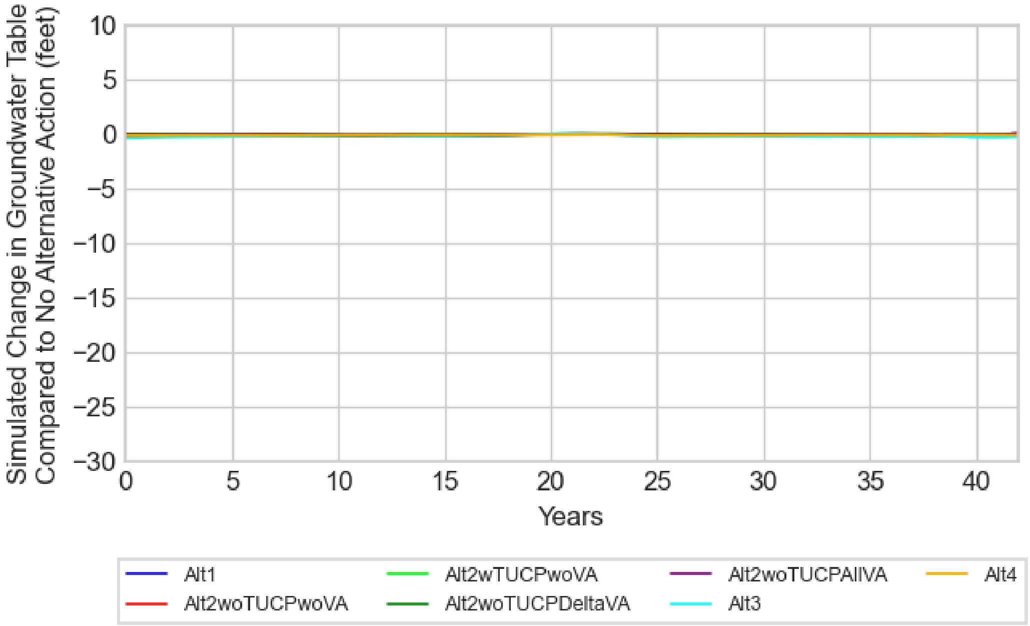


Figure I-31. Simulated Change in Groundwater Table Elevation at Location SR8-A

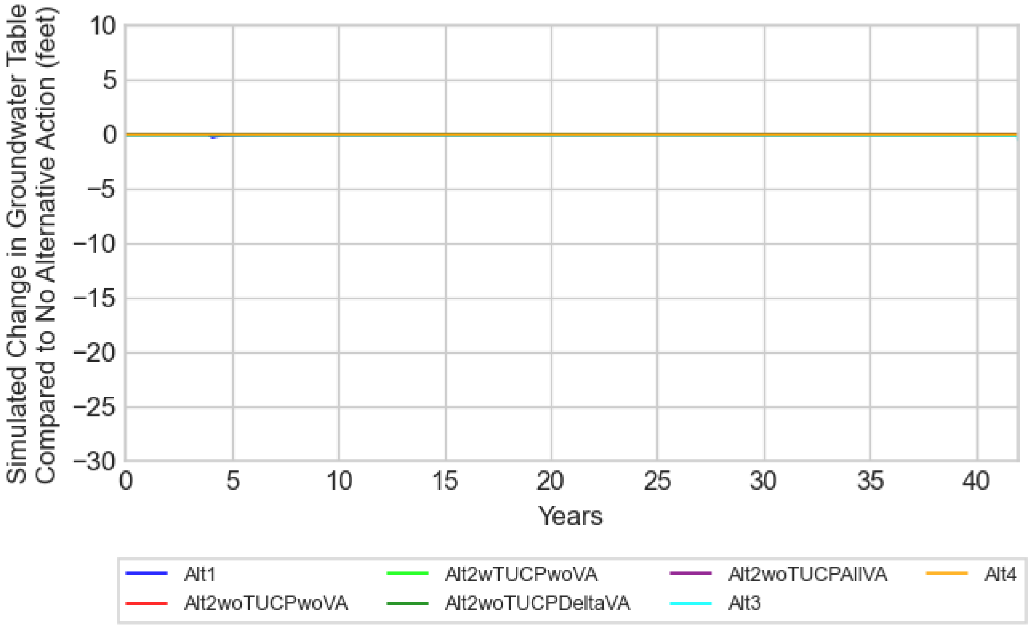


Figure I-32. Simulated Change in Groundwater Table Elevation at Location SR8-B

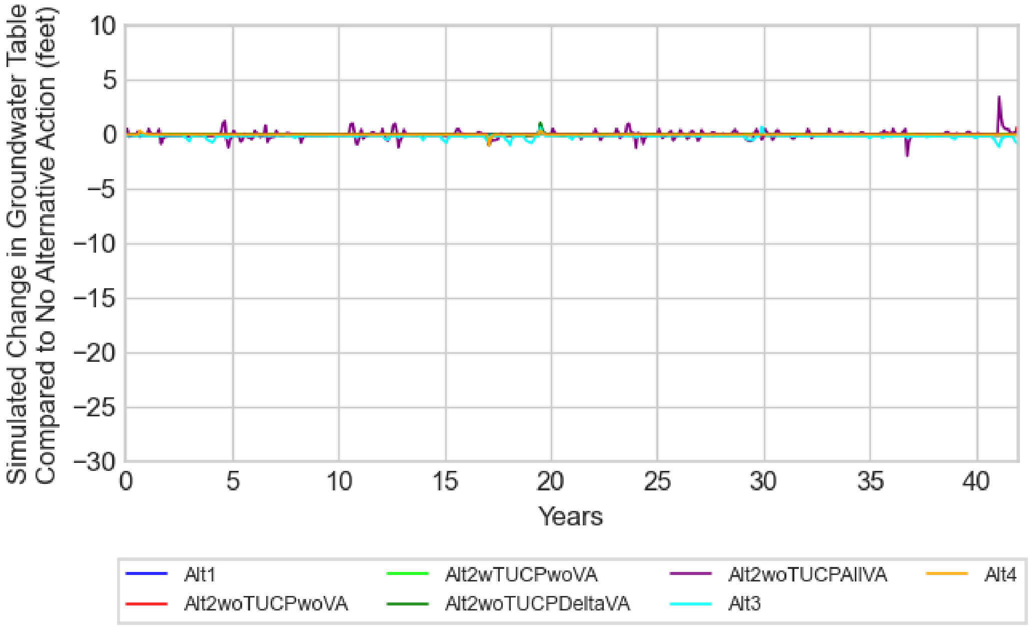


Figure I-33. Simulated Change in Groundwater Table Elevation at Location SR8-C

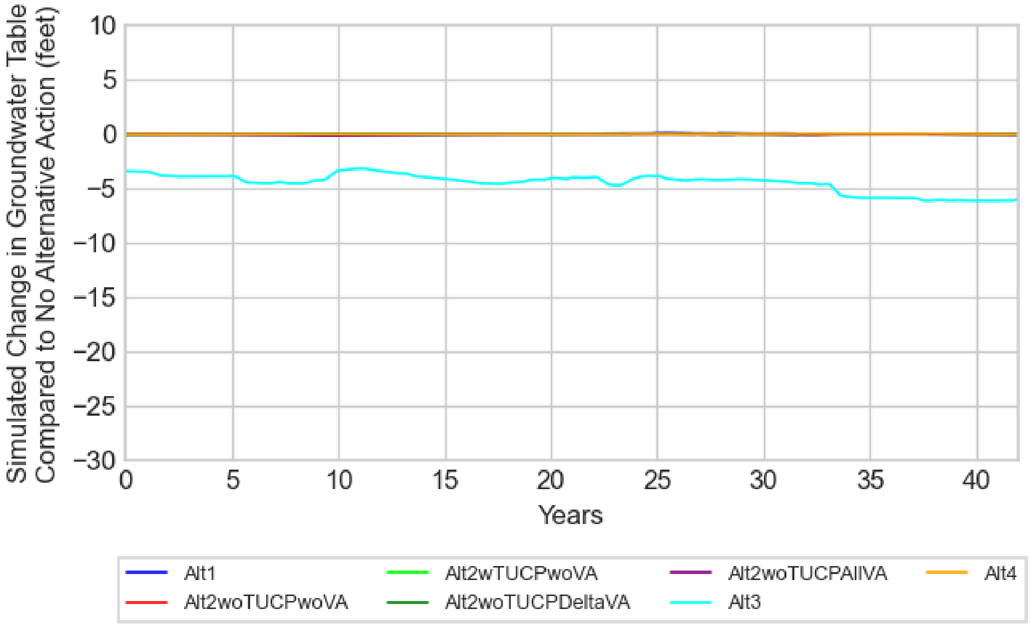


Figure I-34. Simulated Change in Groundwater Table Elevation at Location SR8-D

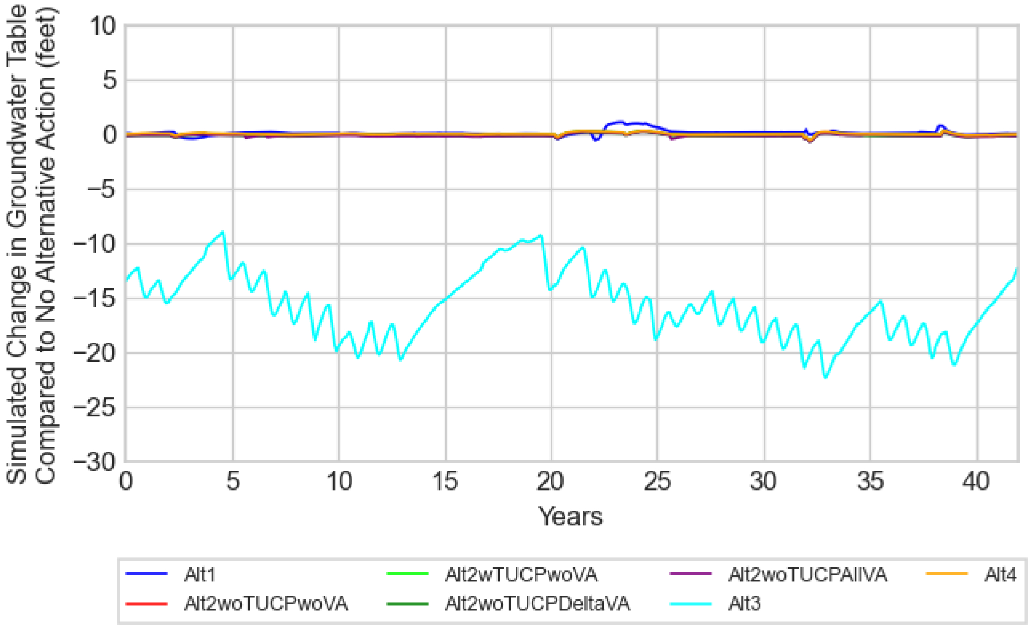


Figure I-35. Simulated Change in Groundwater Table Elevation at Location SR8-E

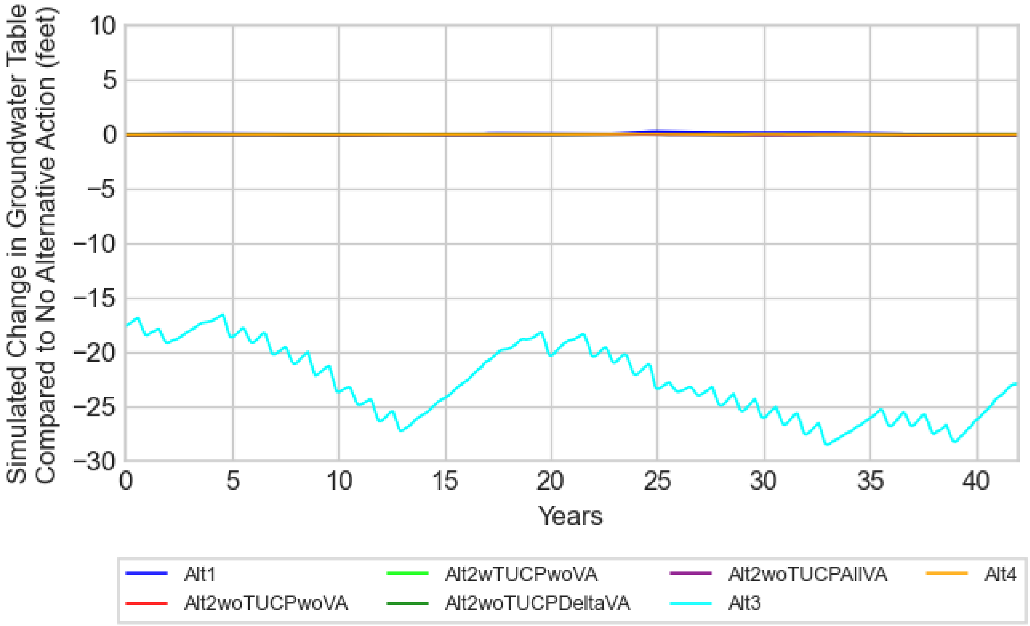


Figure I-36. Simulated Change in Groundwater Table Elevation at Location SR8-F

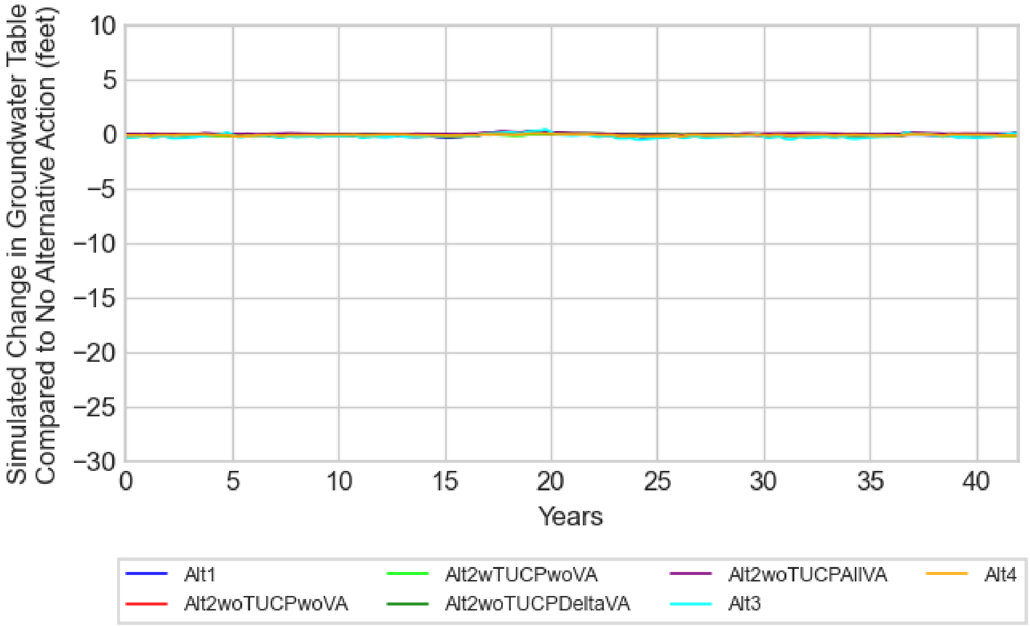


Figure I-37. Simulated Change in Groundwater Table Elevation at Location SR9-A

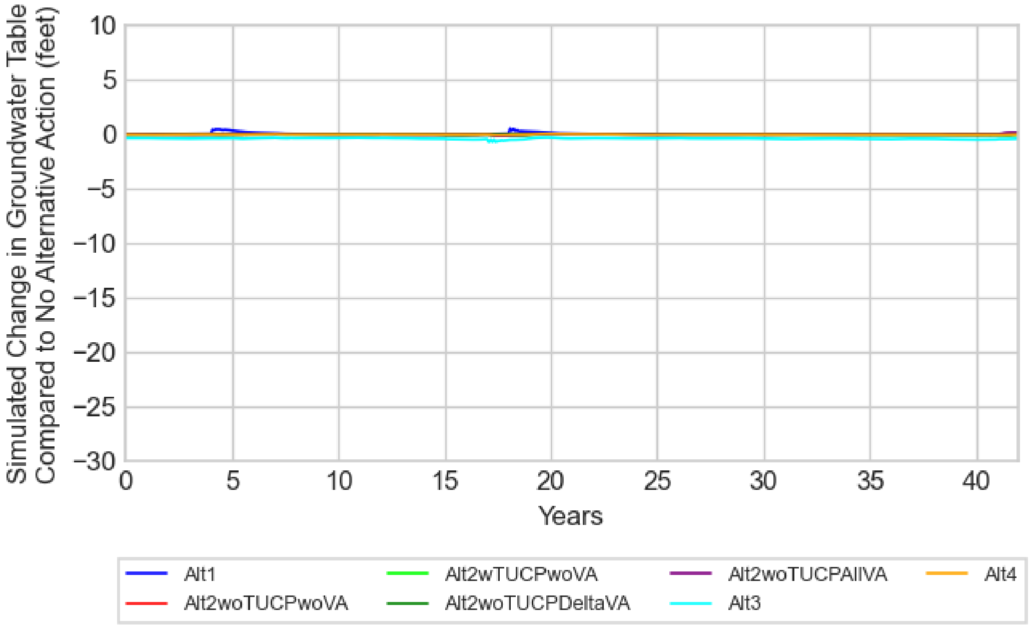


Figure I-38. Simulated Change in Groundwater Table Elevation at Location SR9-B

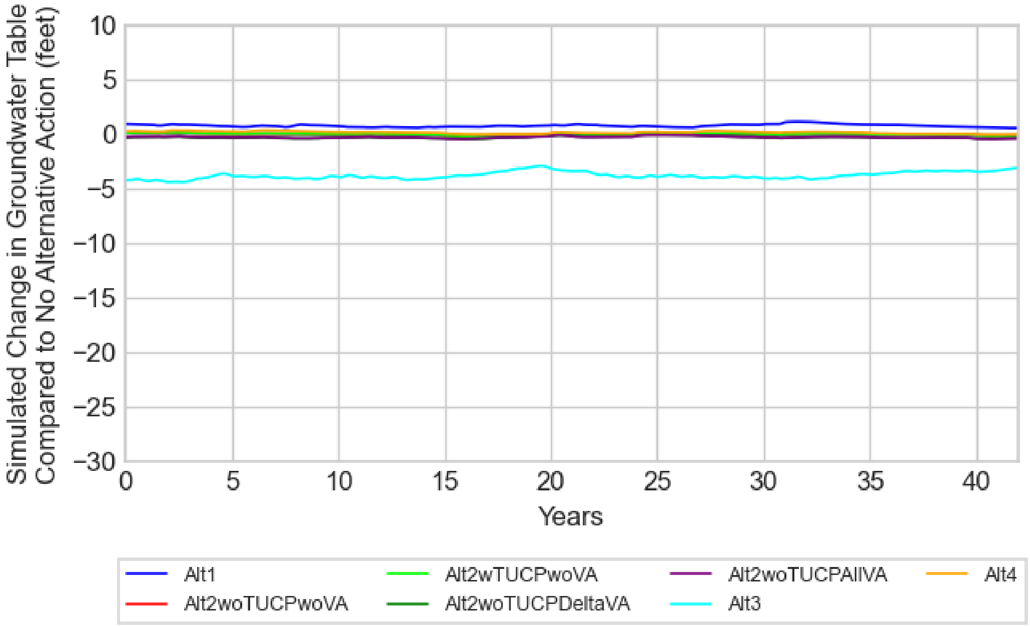


Figure I-39. Simulated Change in Groundwater Table Elevation at Location SR9-C

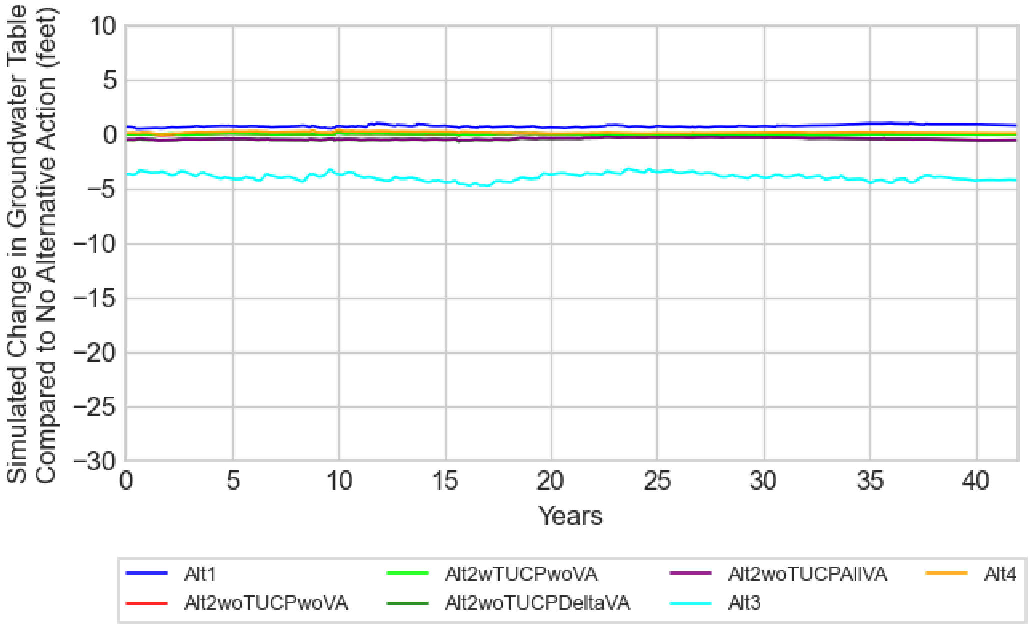


Figure I-40. Simulated Change in Groundwater Table Elevation at Location SR9-D

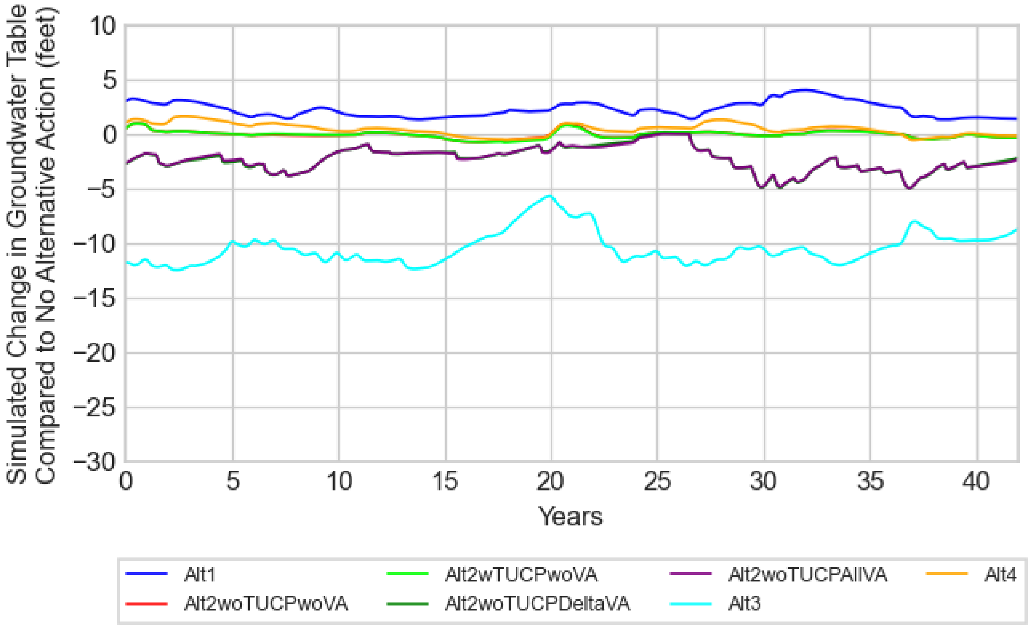


Figure I-41. Simulated Change in Groundwater Table Elevation at Location SR10-A

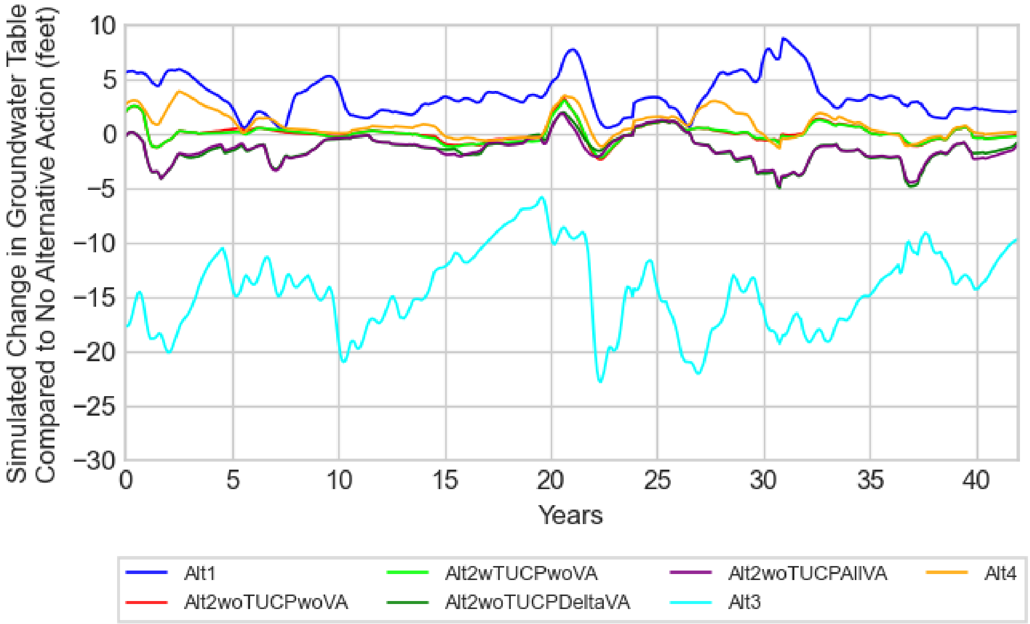


Figure I-42. Simulated Change in Groundwater Table Elevation at Location SR10-B

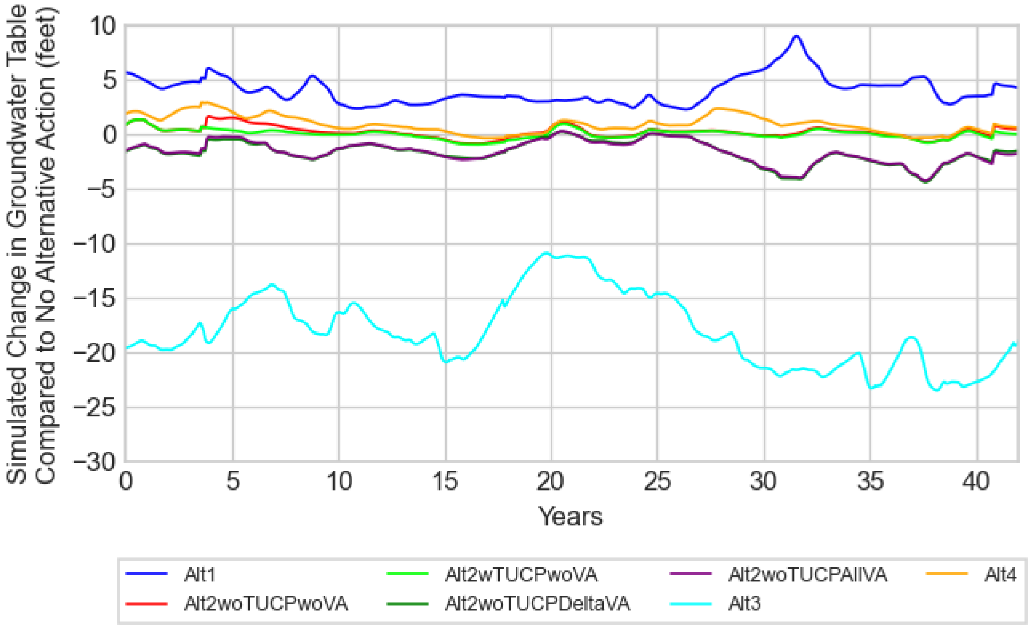


Figure I-43. Simulated Change in Groundwater Table Elevation at Location SR10-C

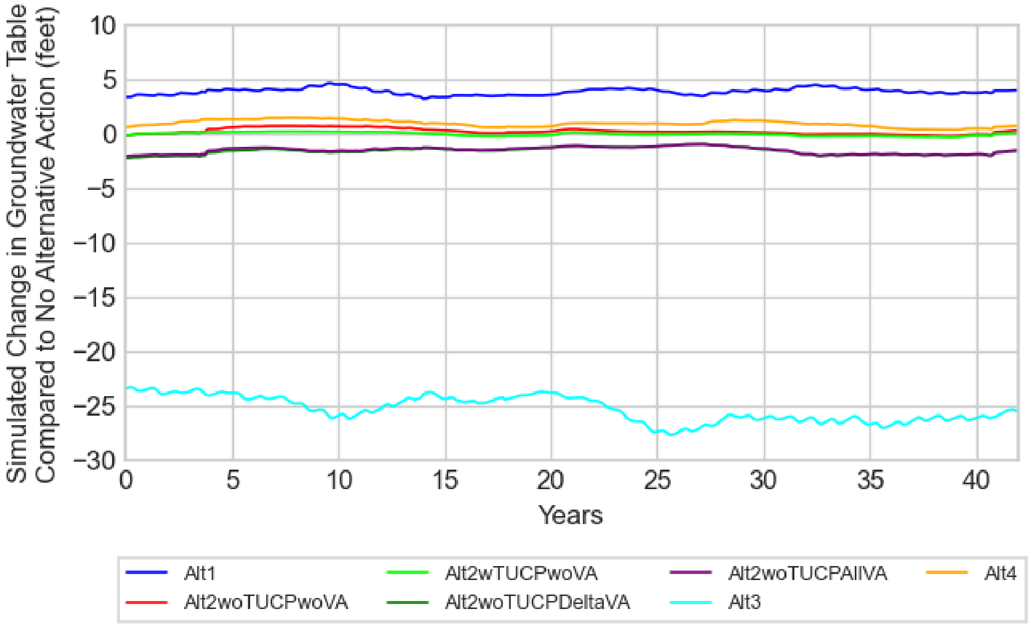


Figure I-44. Simulated Change in Groundwater Table Elevation at Location SR10-D

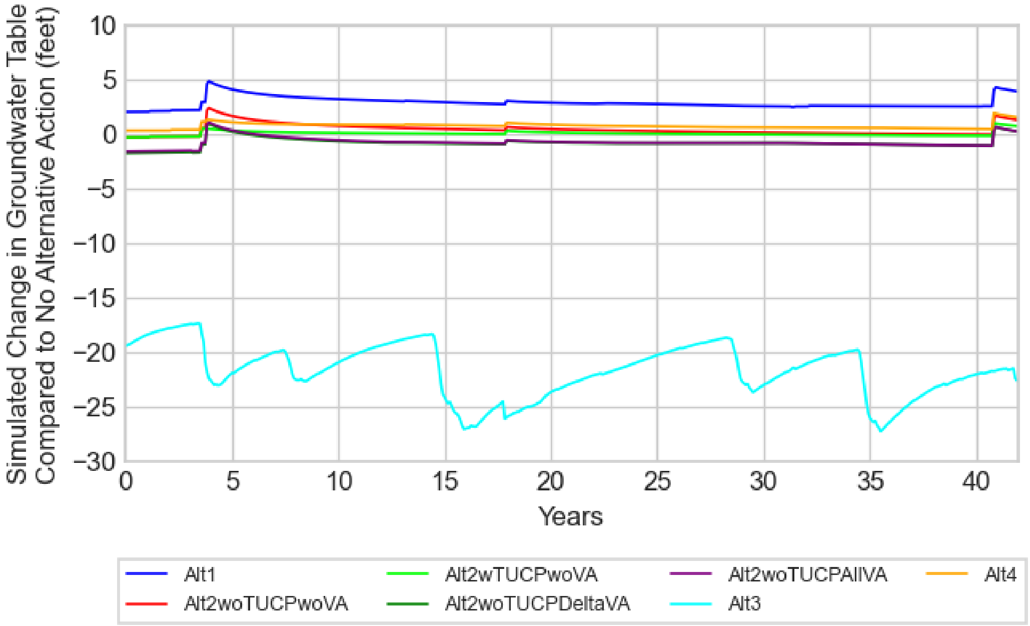


Figure I-45. Simulated Change in Groundwater Table Elevation at Location SR10-E

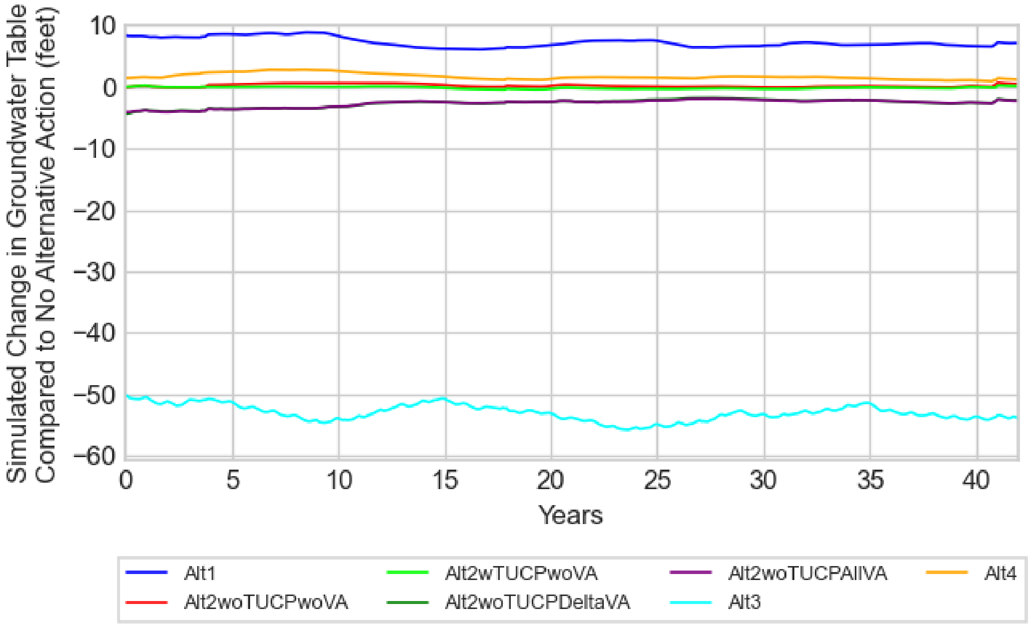


Figure I-46. Simulated Change in Groundwater Table Elevation at Location SR10-F

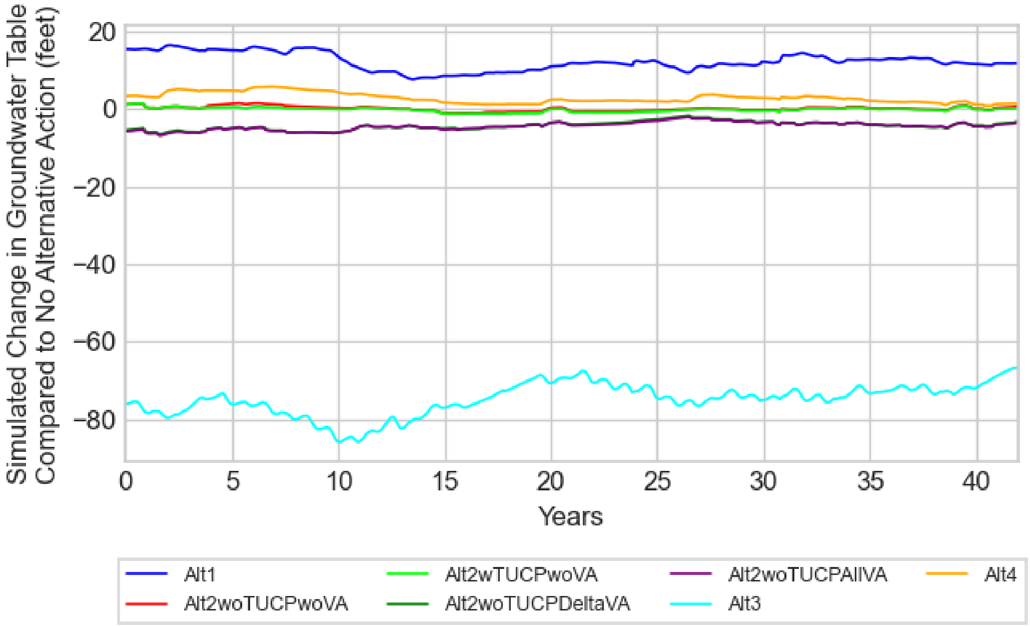


Figure I-47. Simulated Change in Groundwater Table Elevation at Location SR10-G

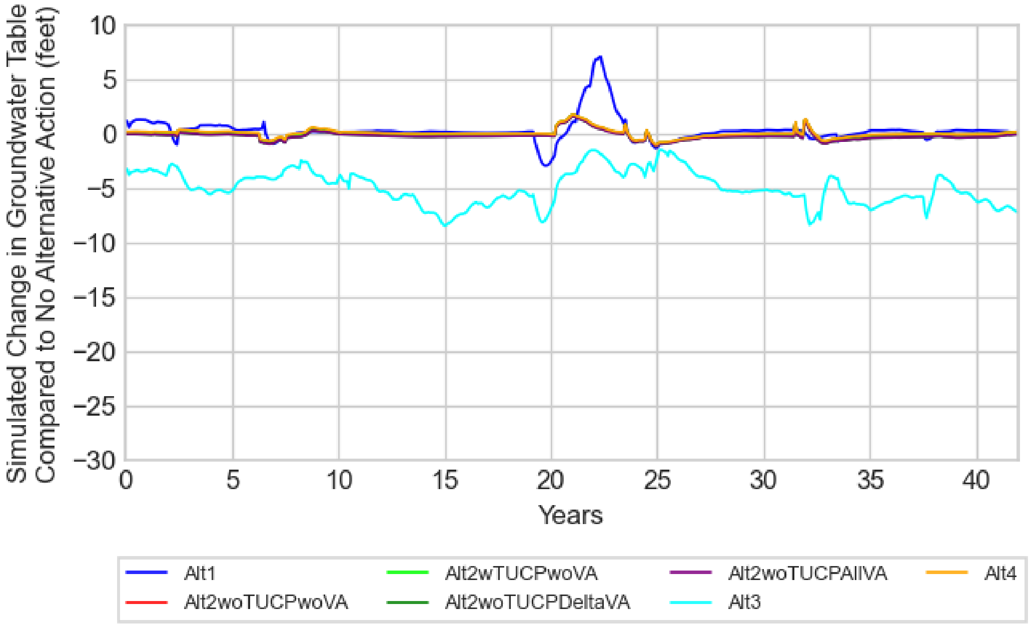


Figure I-48. Simulated Change in Groundwater Table Elevation at Location SR11-A

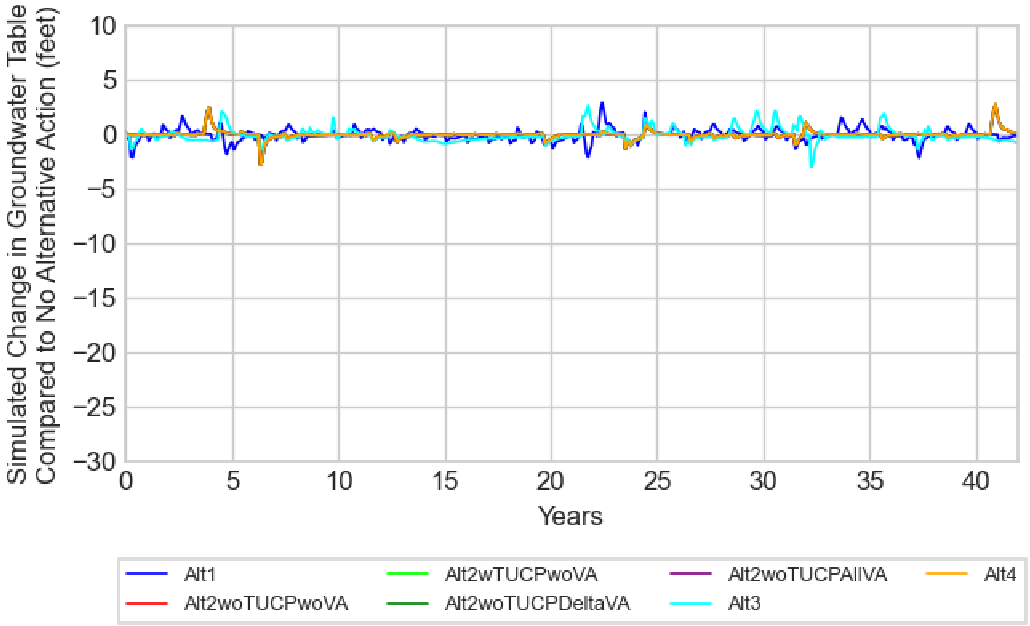


Figure I-49. Simulated Change in Groundwater Table Elevation at Location SR11-B

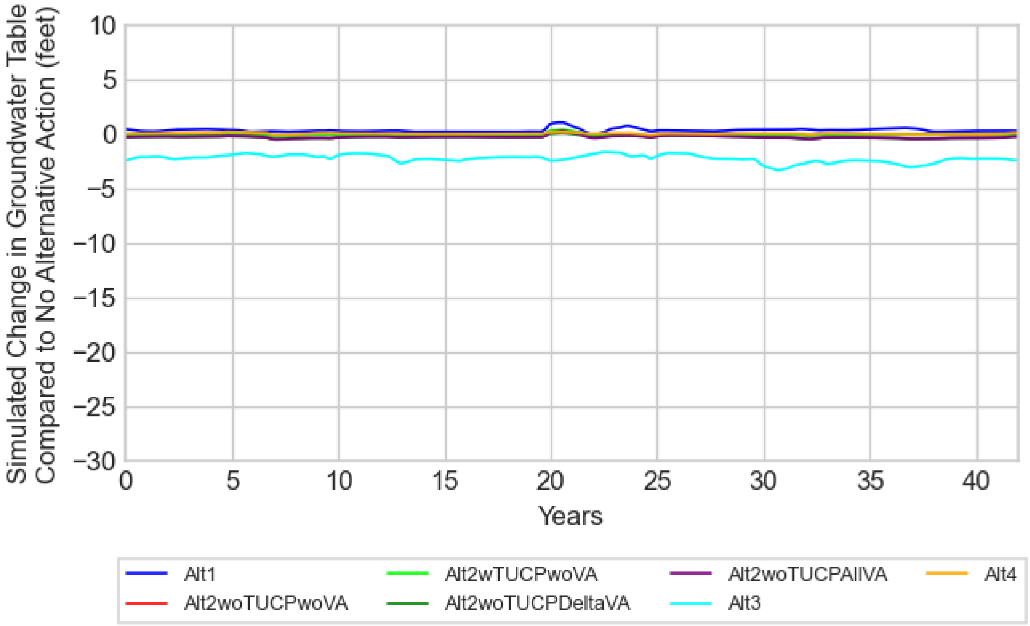


Figure I-50. Simulated Change in Groundwater Table Elevation at Location SR11-C

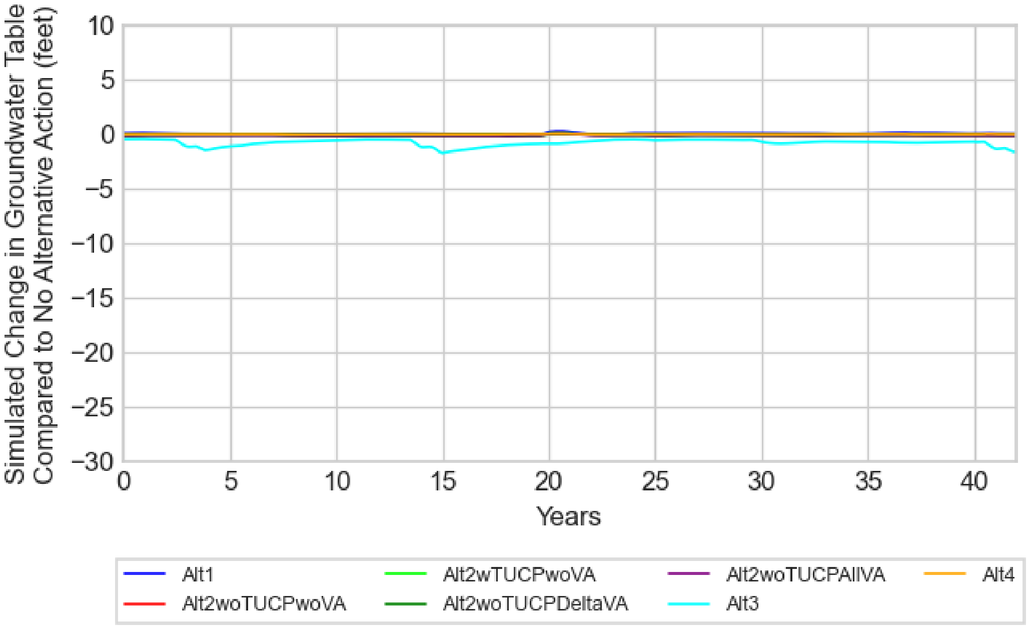


Figure I-51. Simulated Change in Groundwater Table Elevation at Location SR11-D

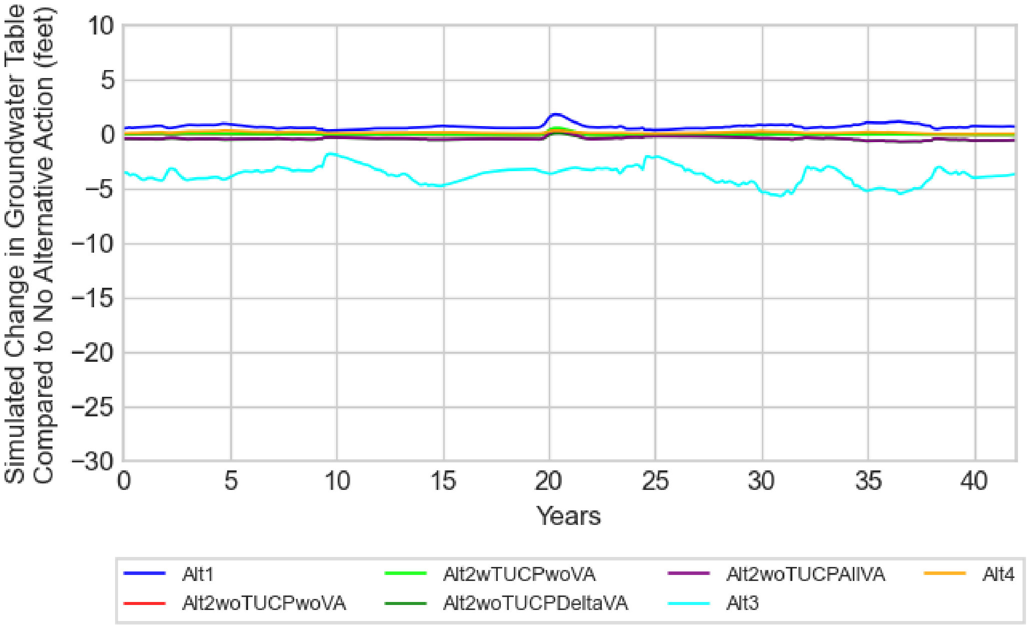


Figure I-52. Simulated Change in Groundwater Table Elevation at Location SR12-A

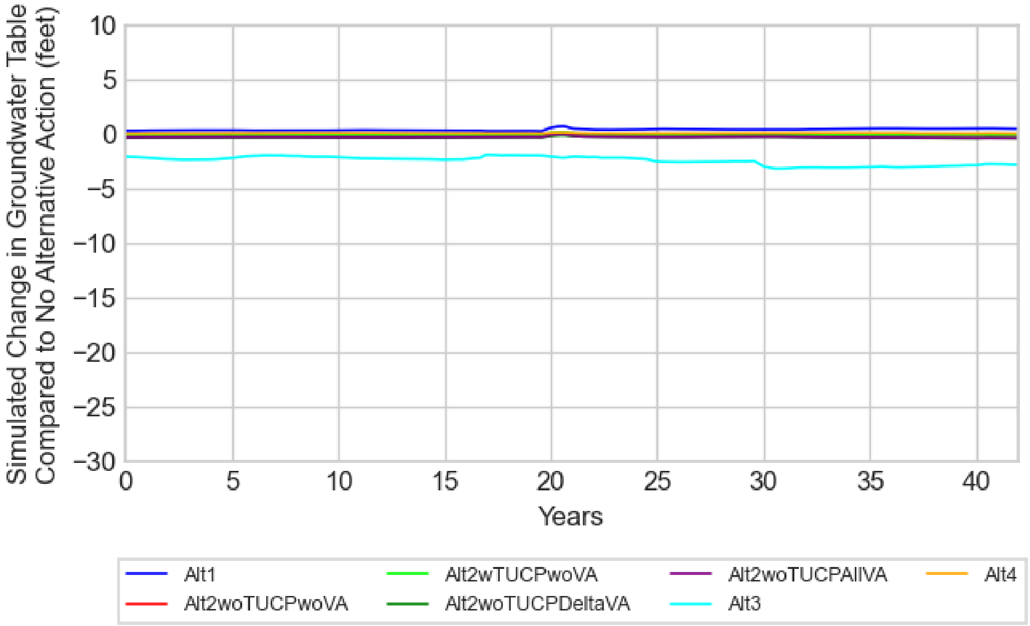


Figure I-53. Simulated Change in Groundwater Table Elevation at Location SR12-B

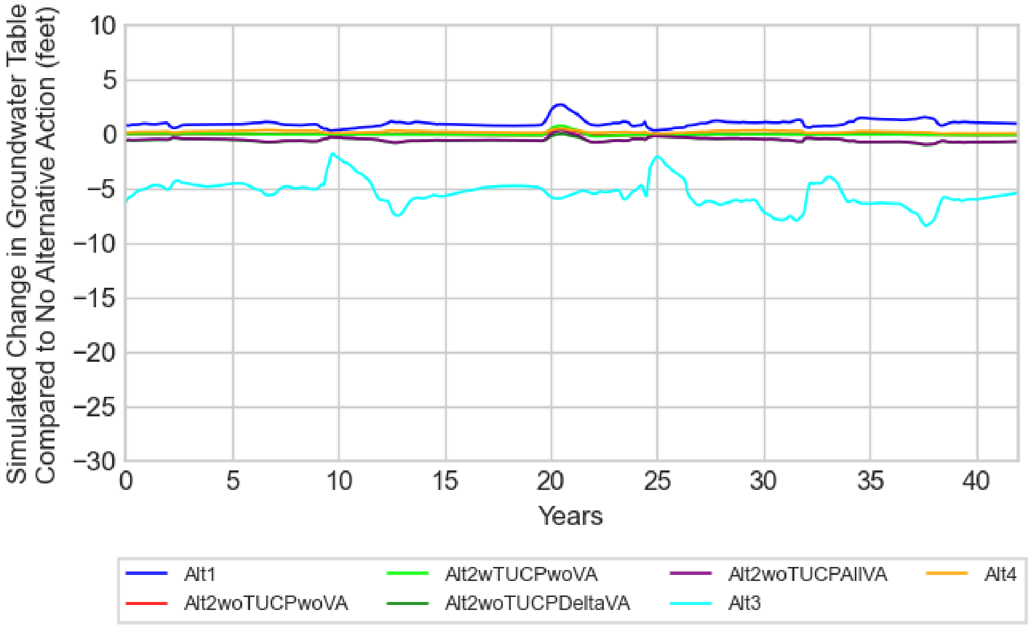


Figure I-54. Simulated Change in Groundwater Table Elevation at Location SR12-C

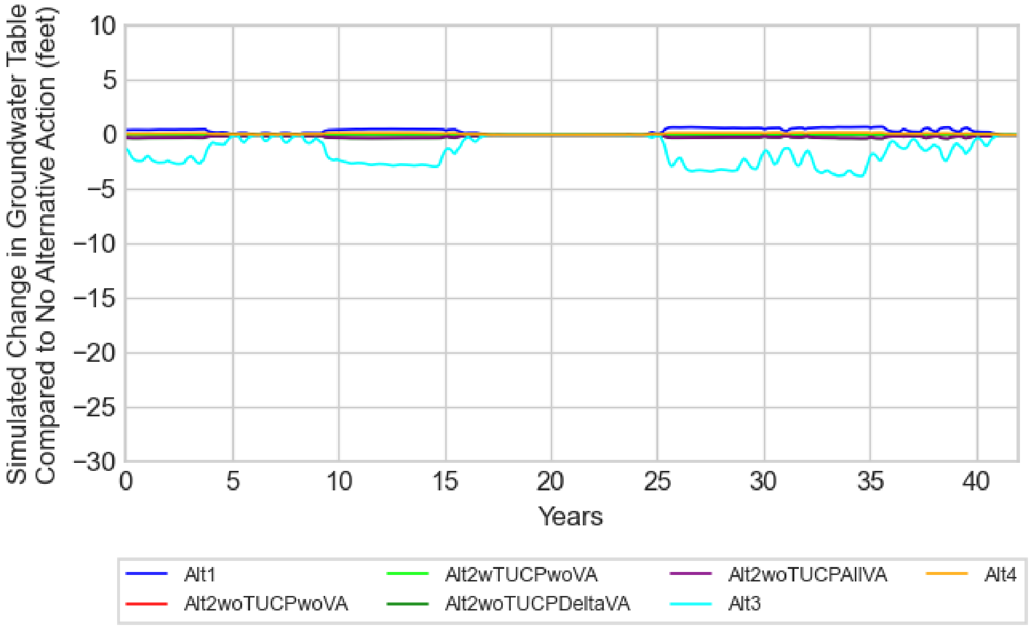


Figure I-55. Simulated Change in Groundwater Table Elevation at Location SR12-D

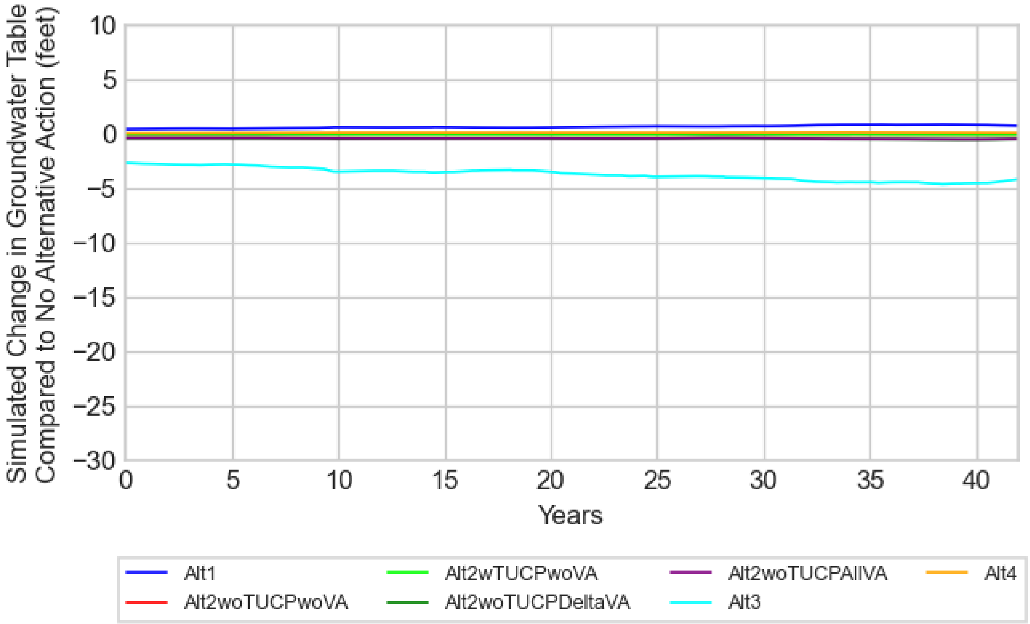


Figure I-56. Simulated Change in Groundwater Table Elevation at Location SR13-A

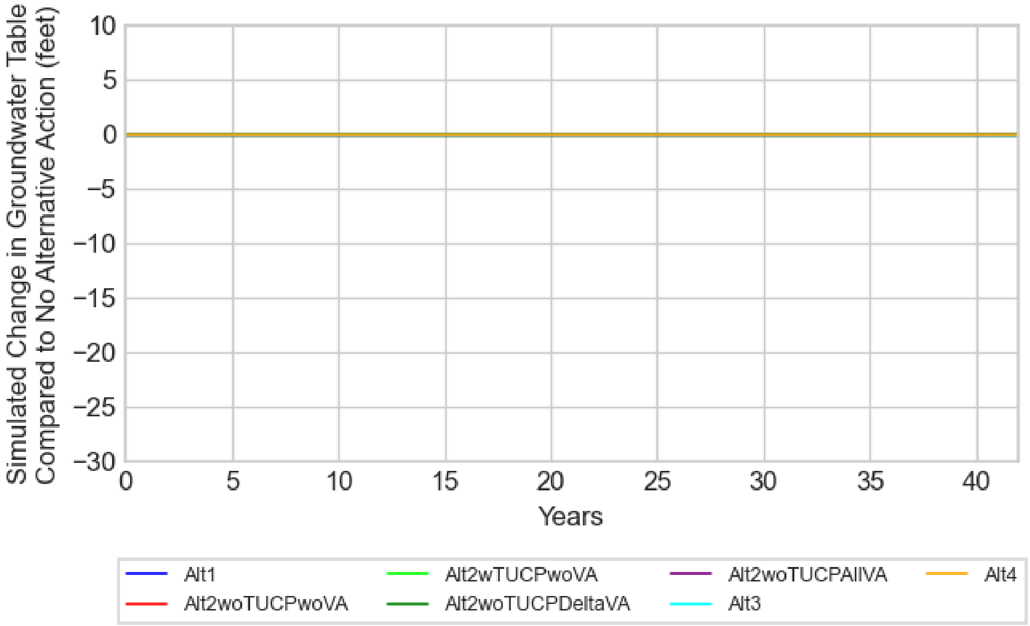


Figure I-57. Simulated Change in Groundwater Table Elevation at Location SR13-B

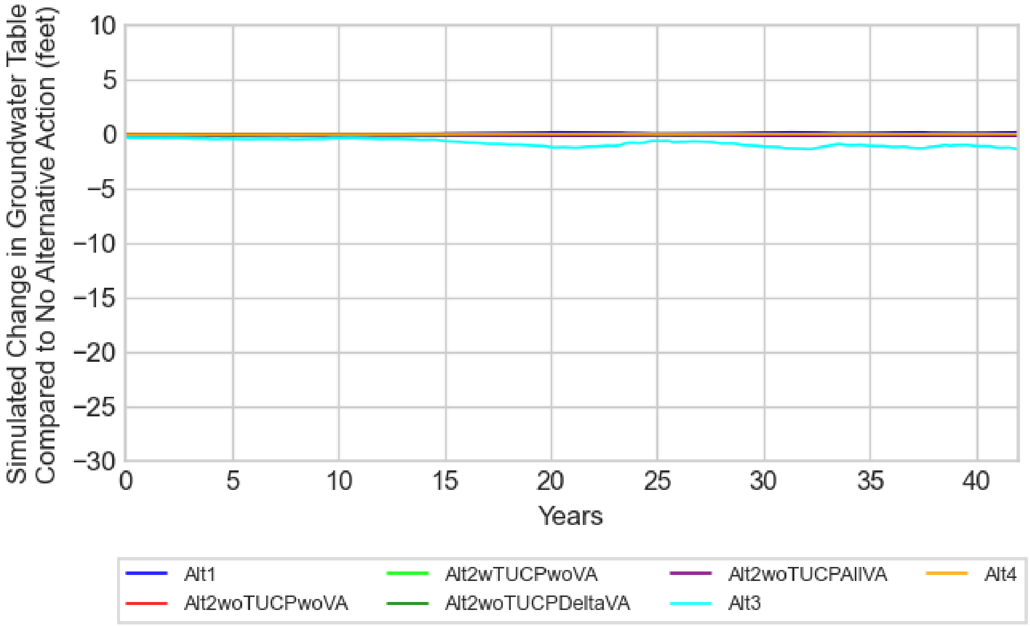


Figure I-58. Simulated Change in Groundwater Table Elevation at Location SR13-C

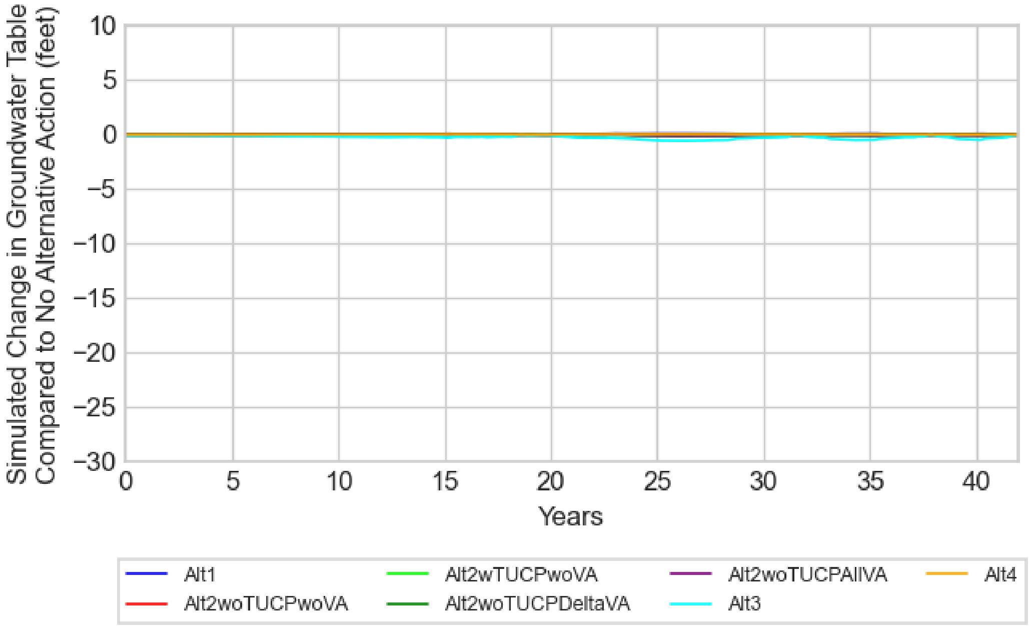


Figure I-59. Simulated Change in Groundwater Table Elevation at Location SR13-D

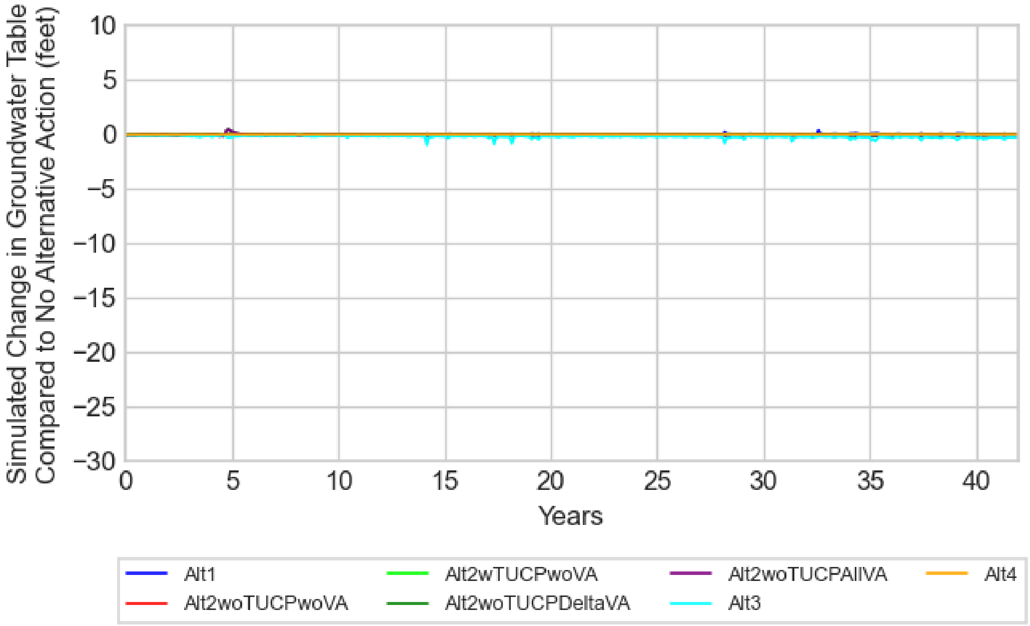


Figure I-60. Simulated Change in Groundwater Table Elevation at Location SR13-E

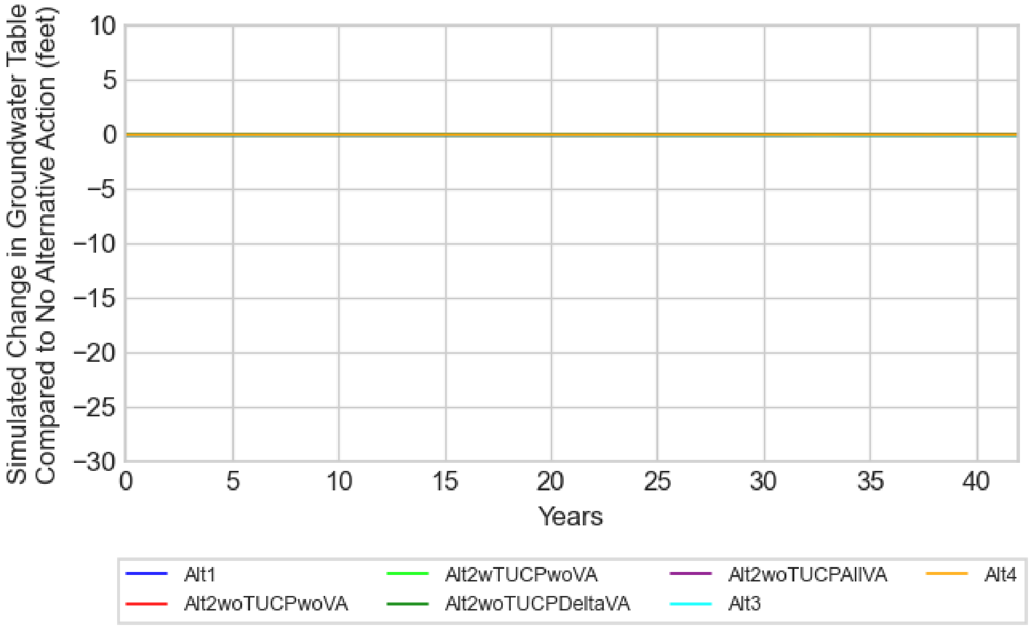


Figure I-61. Simulated Change in Groundwater Table Elevation at Location SR13-F

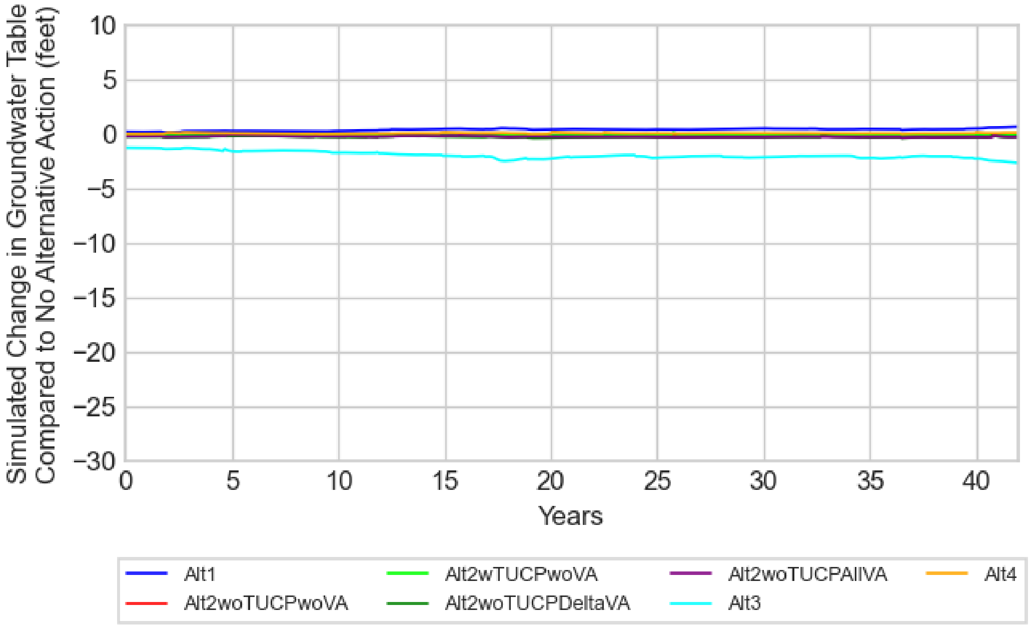


Figure I-62. Simulated Change in Groundwater Table Elevation at Location SR13-G

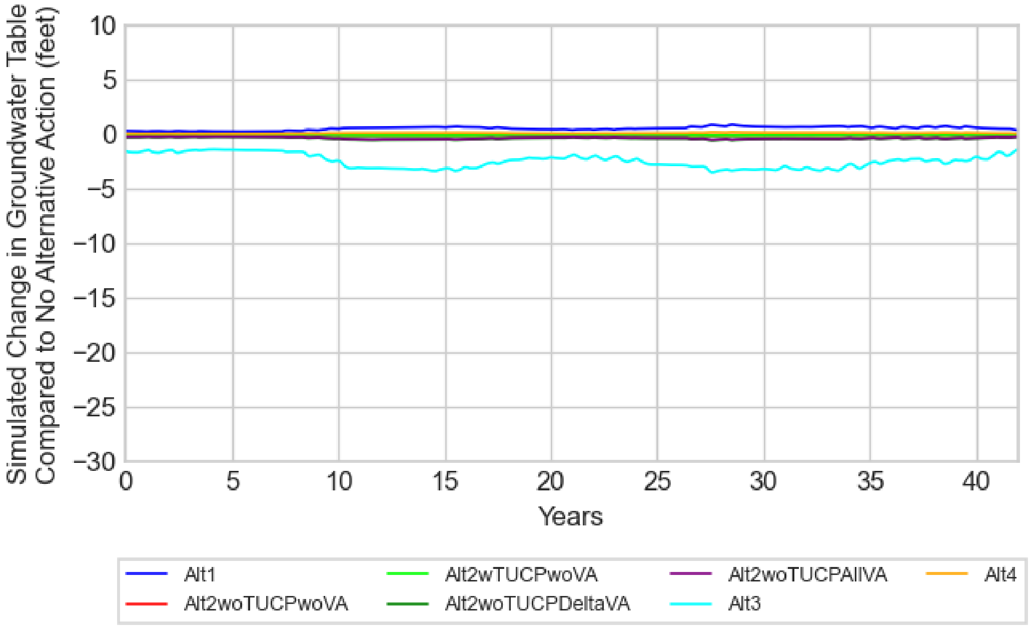


Figure I-63. Simulated Change in Groundwater Table Elevation at Location SR13-H

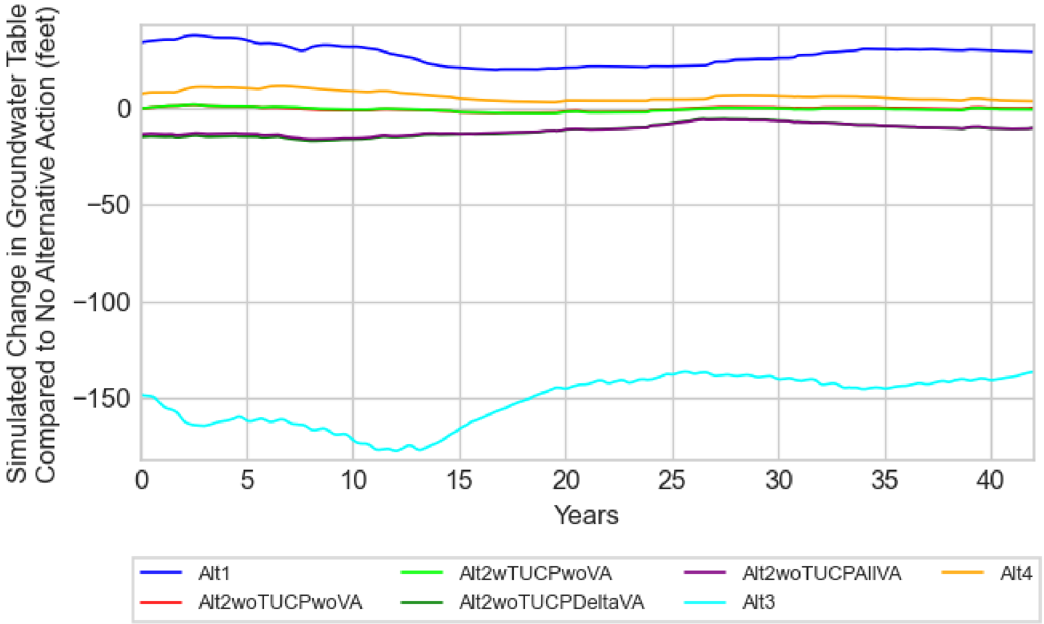


Figure I-64. Simulated Change in Groundwater Table Elevation at Location SR14-A

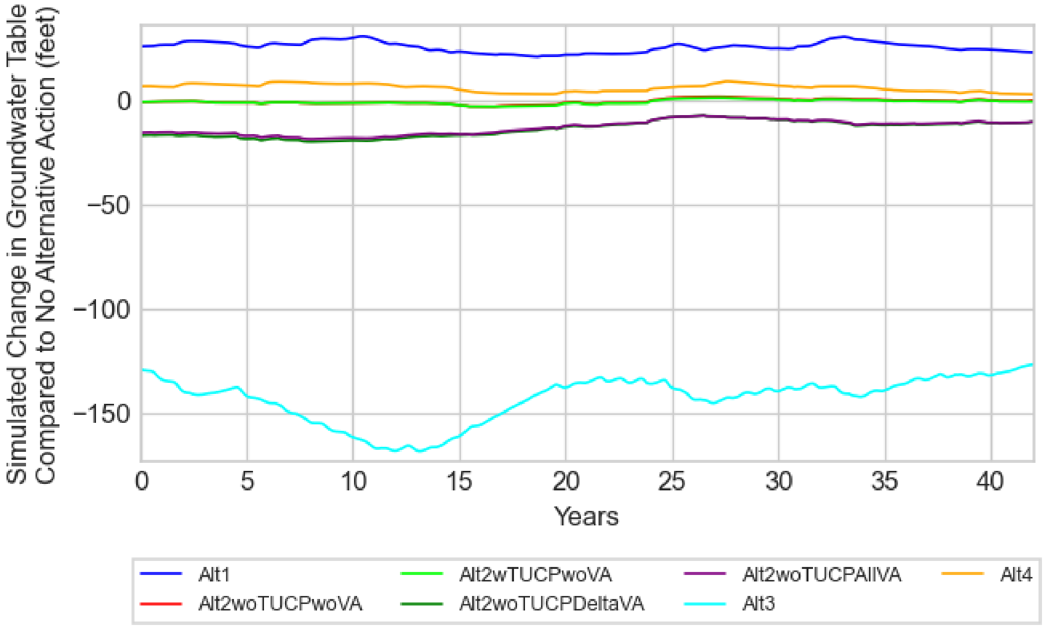


Figure I-65. Simulated Change in Groundwater Table Elevation at Location SR14-B

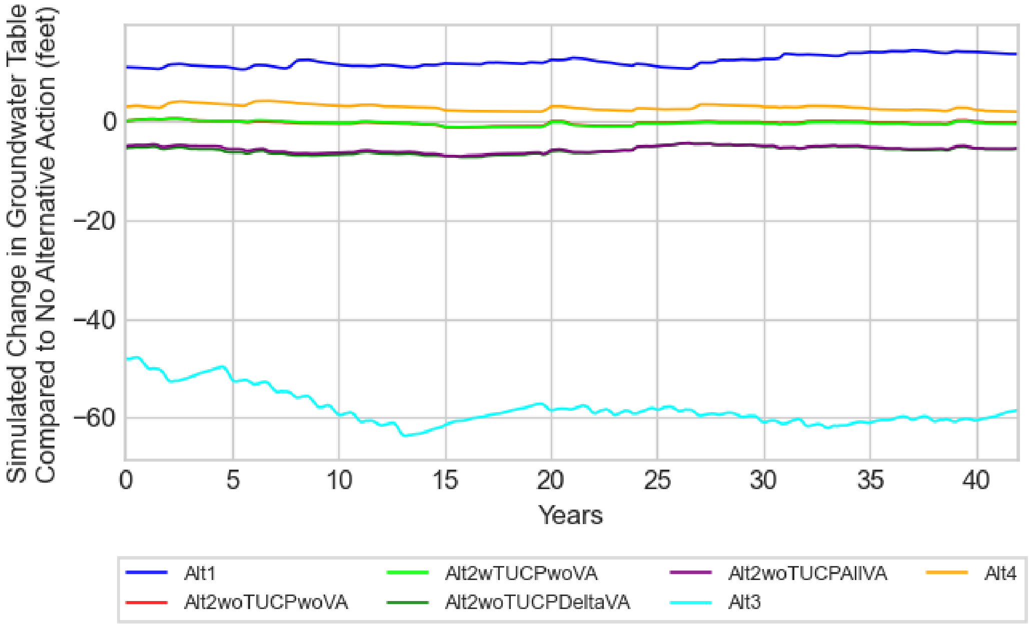


Figure I-66. Simulated Change in Groundwater Table Elevation at Location SR14-C

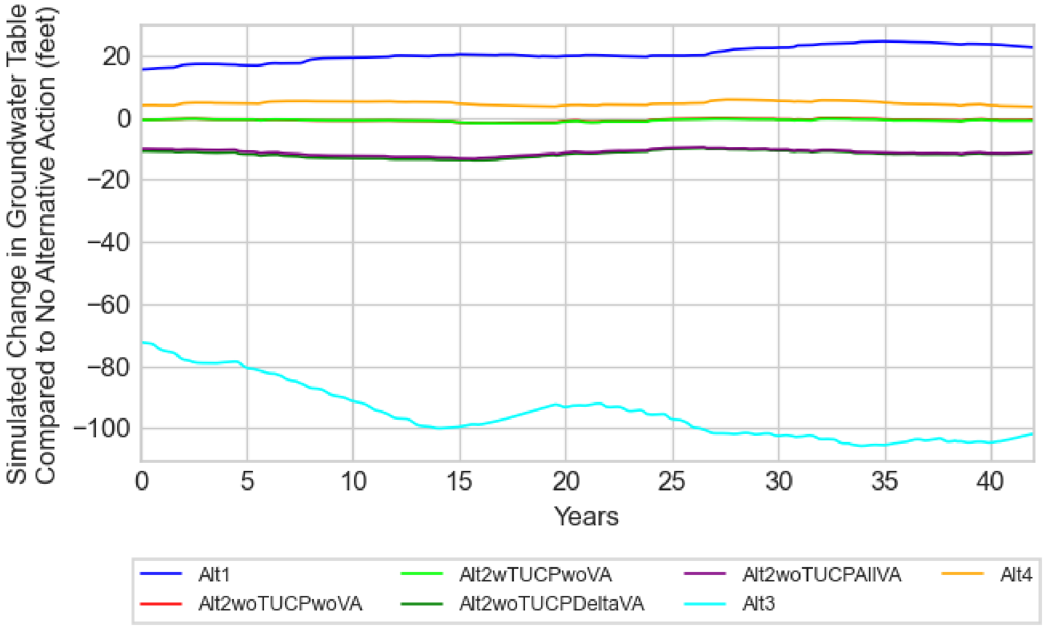


Figure I-67. Simulated Change in Groundwater Table Elevation at Location SR14-D

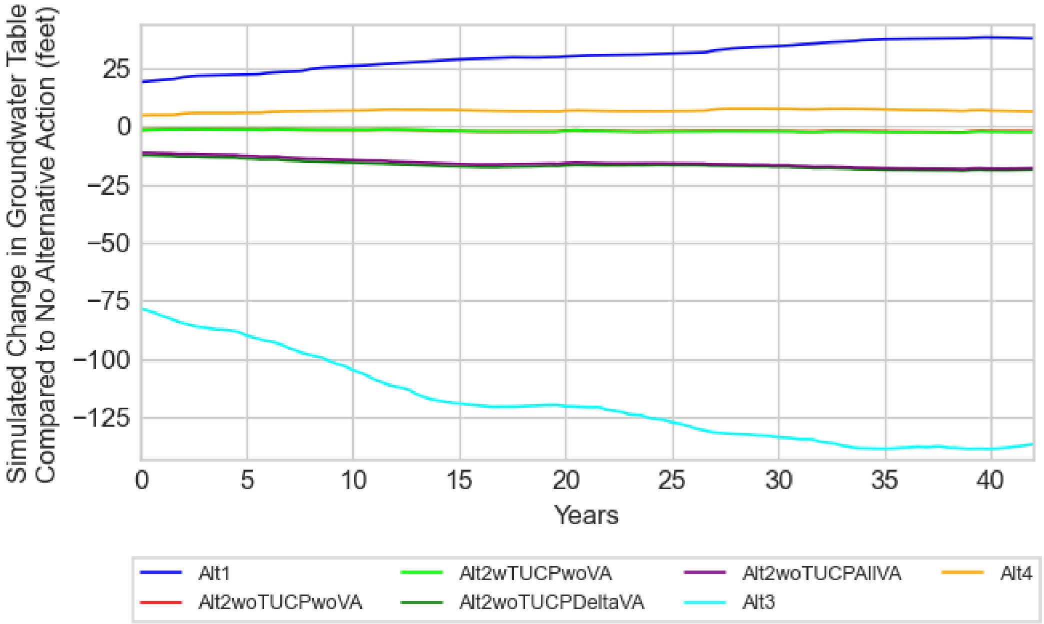


Figure I-68. Simulated Change in Groundwater Table Elevation at Location SR14-E

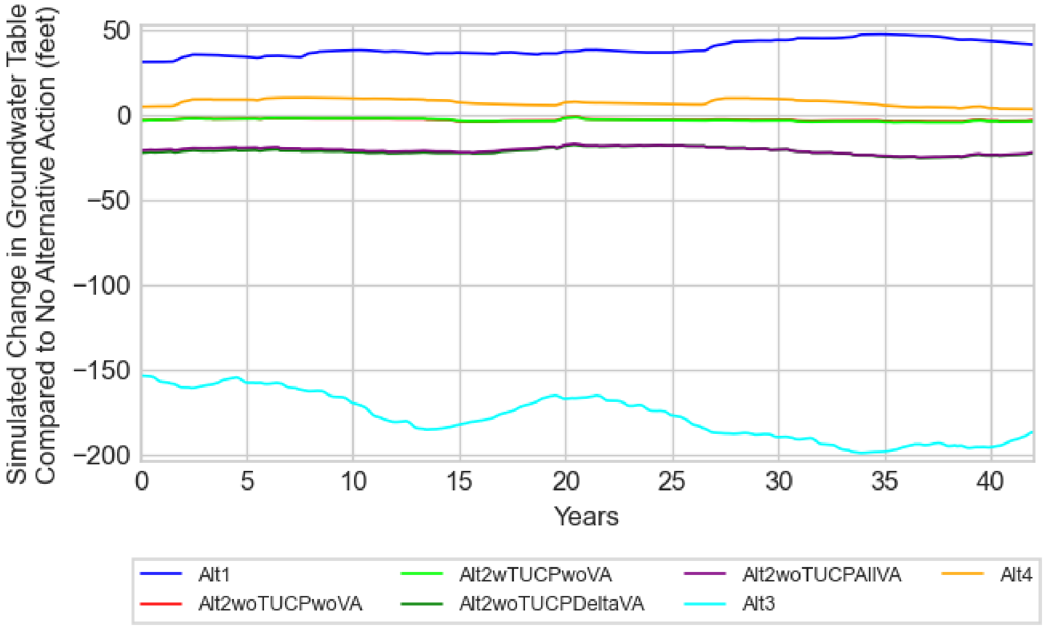


Figure I-69. Simulated Change in Groundwater Table Elevation at Location SR14-F

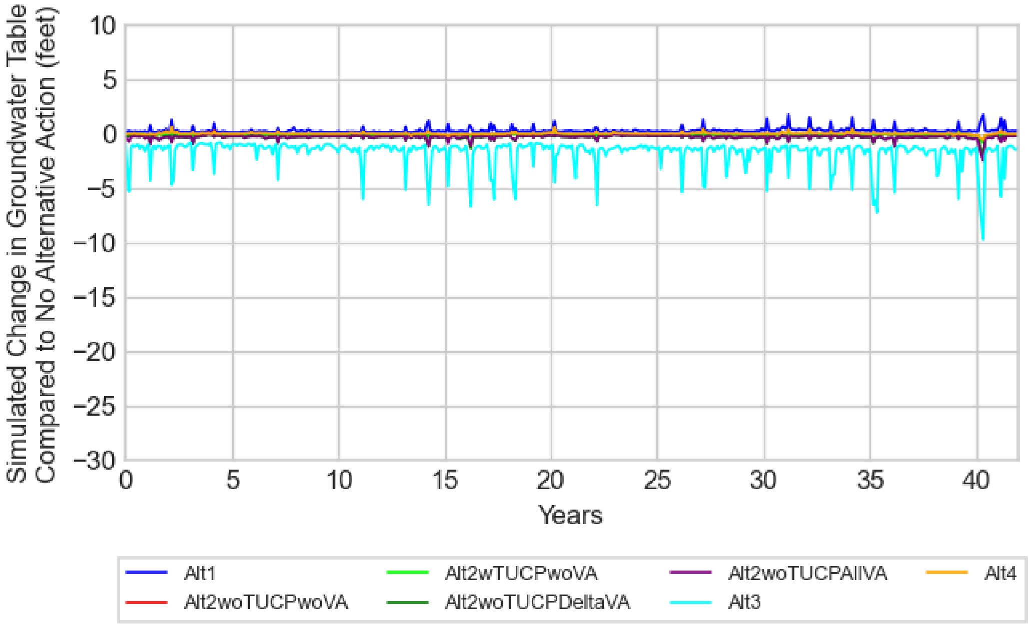


Figure I-70. Simulated Change in Groundwater Table Elevation at Location SR15-A

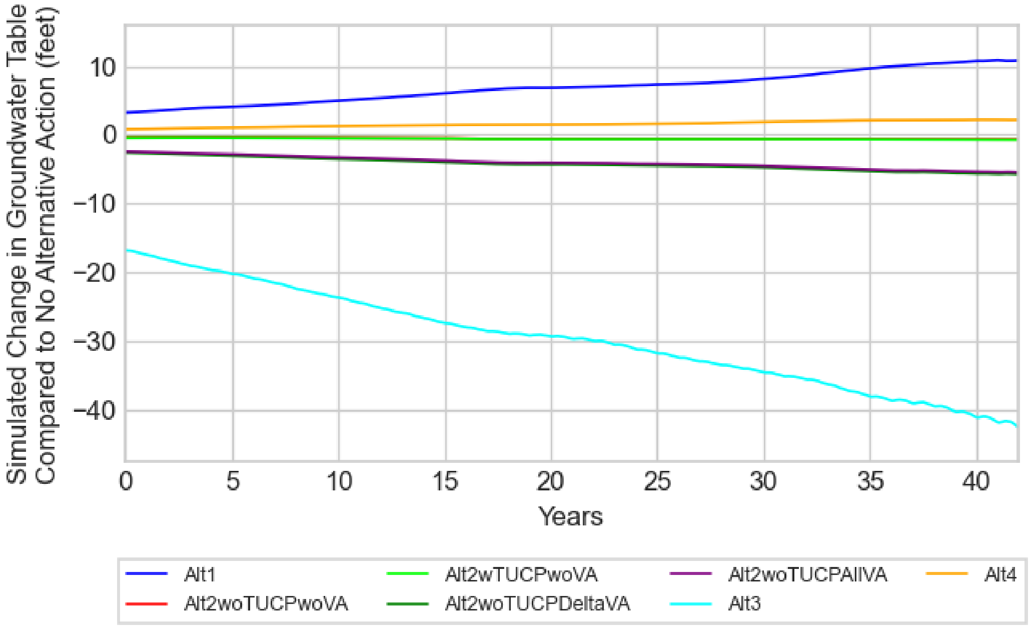


Figure I-71. Simulated Change in Groundwater Table Elevation at Location SR15-B

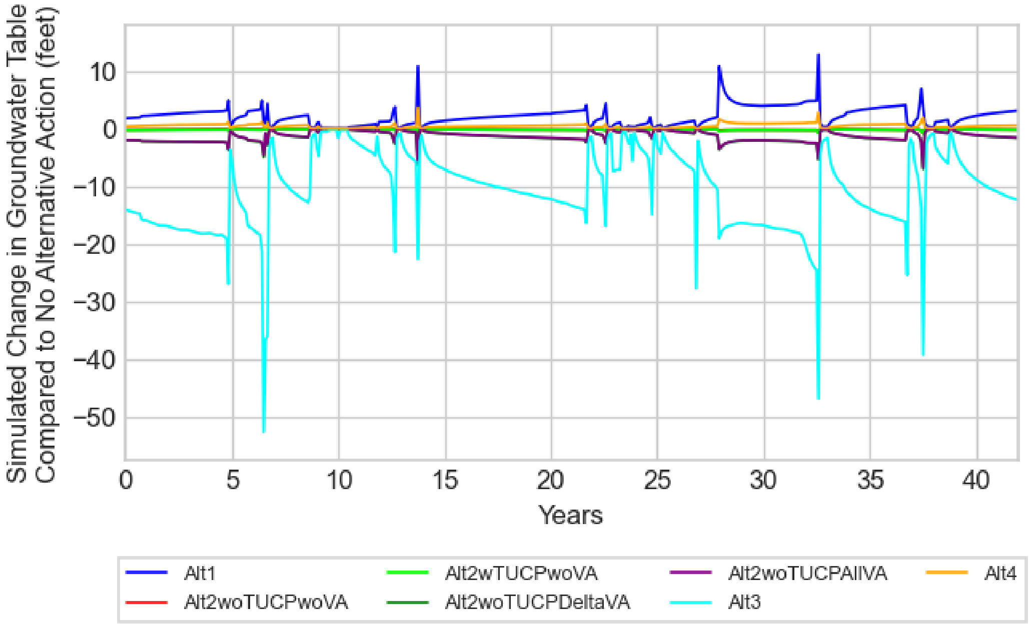


Figure I-72. Simulated Change in Groundwater Table Elevation at Location SR15-C

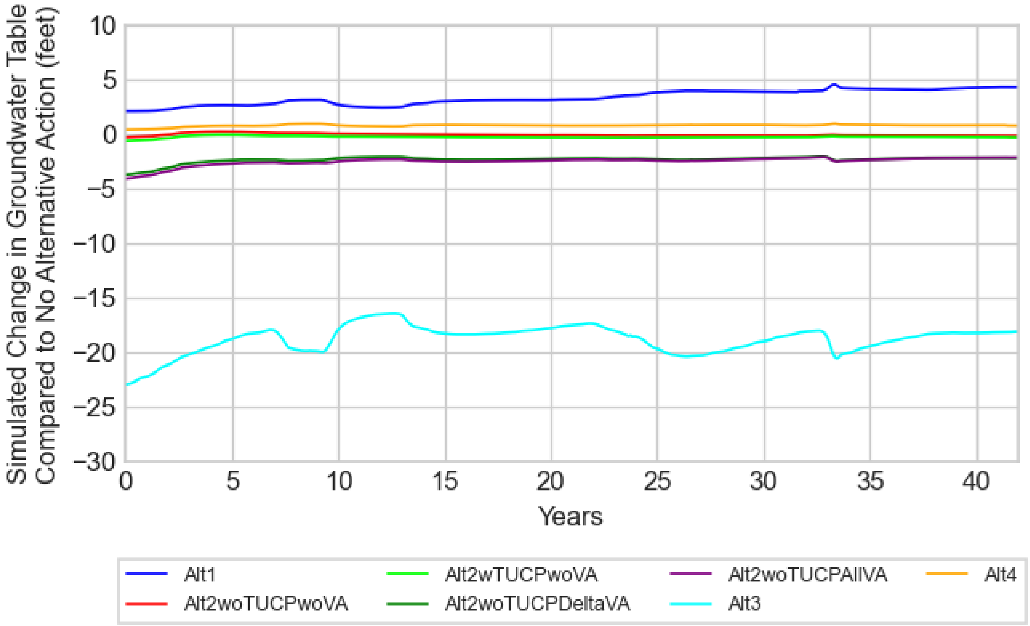


Figure I-73. Simulated Change in Groundwater Table Elevation at Location SR15-D

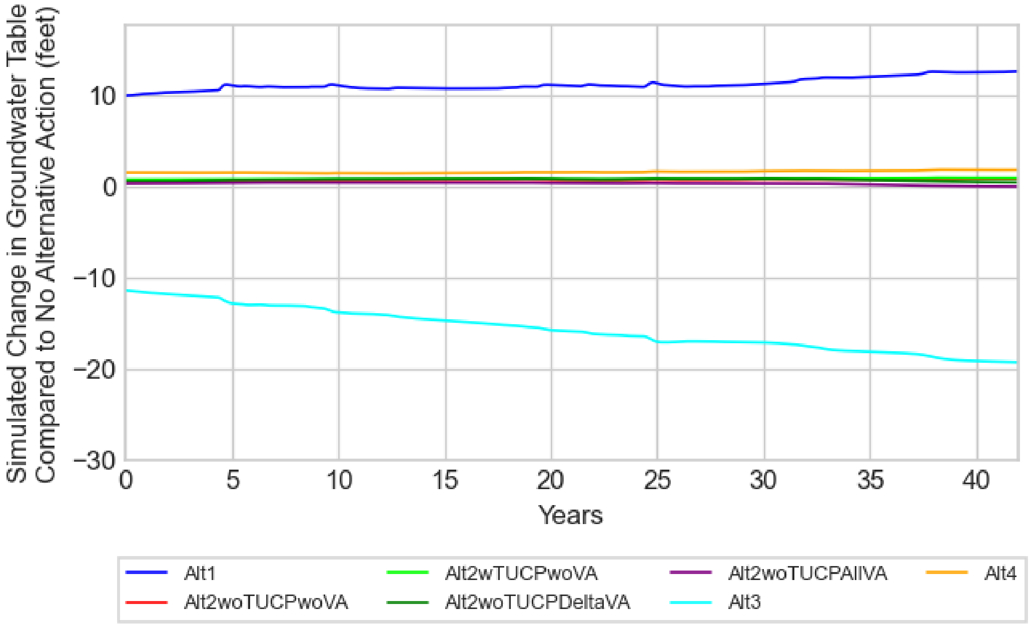


Figure I-74. Simulated Change in Groundwater Table Elevation at Location SR15-E

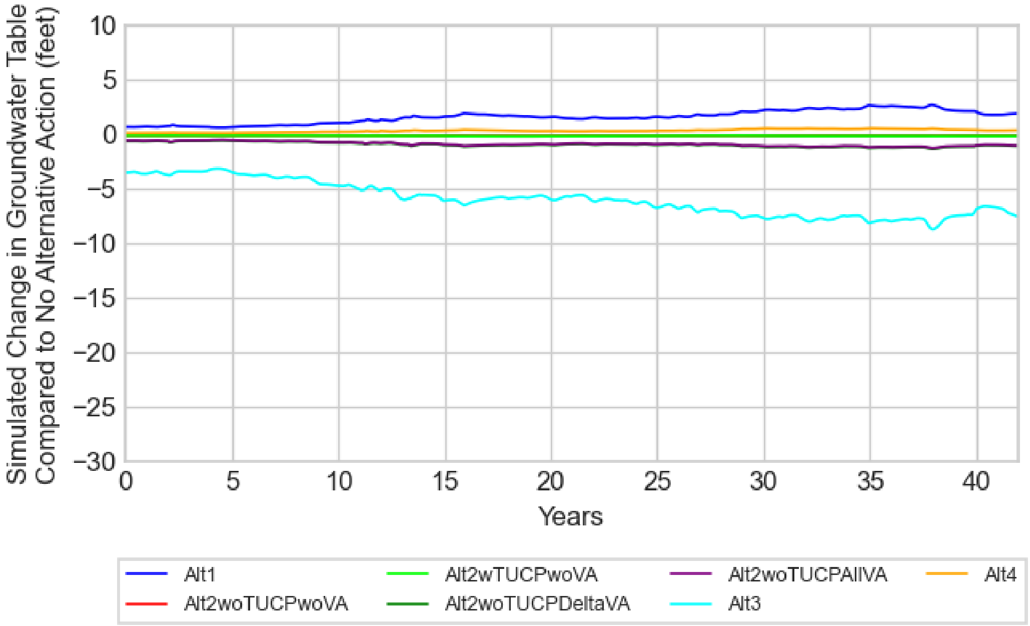


Figure I-75. Simulated Change in Groundwater Table Elevation at Location SR16-A

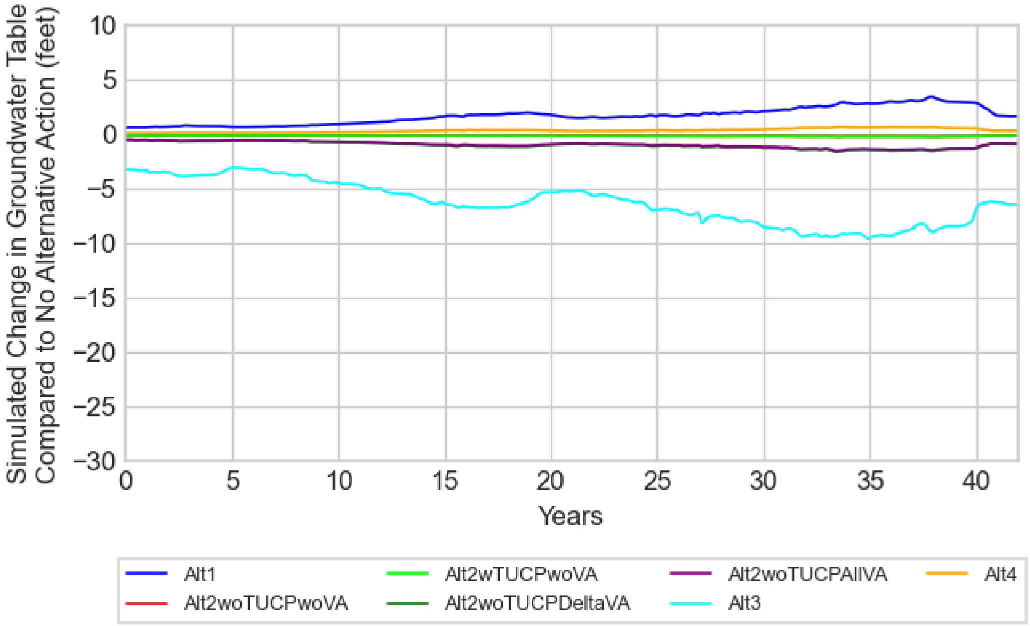


Figure I-76. Simulated Change in Groundwater Table Elevation at Location SR16-B

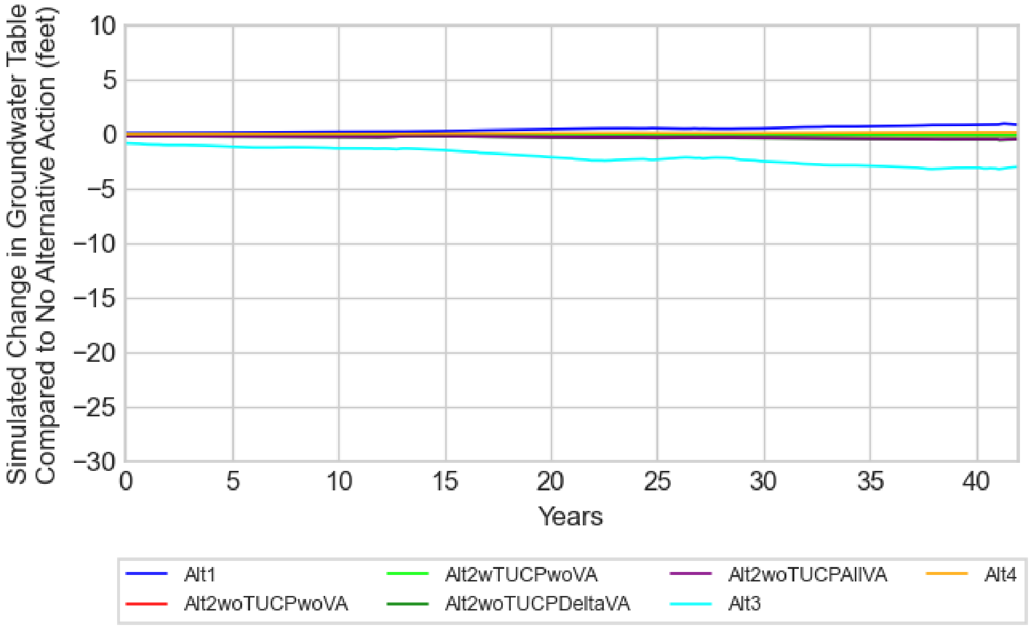


Figure I-77. Simulated Change in Groundwater Table Elevation at Location SR16-C

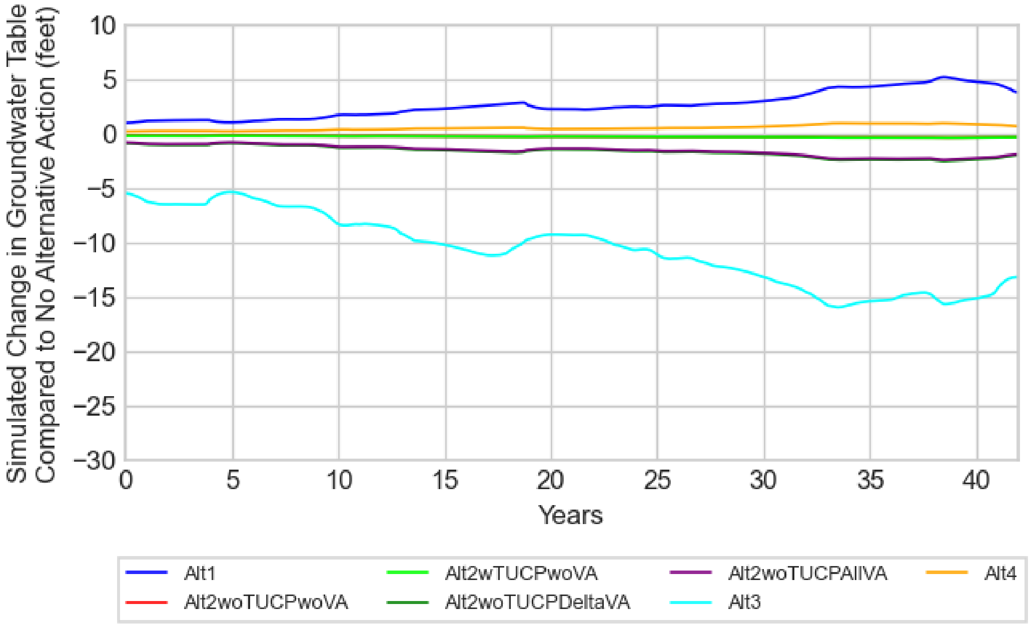


Figure I-78. Simulated Change in Groundwater Table Elevation at Location SR17-A

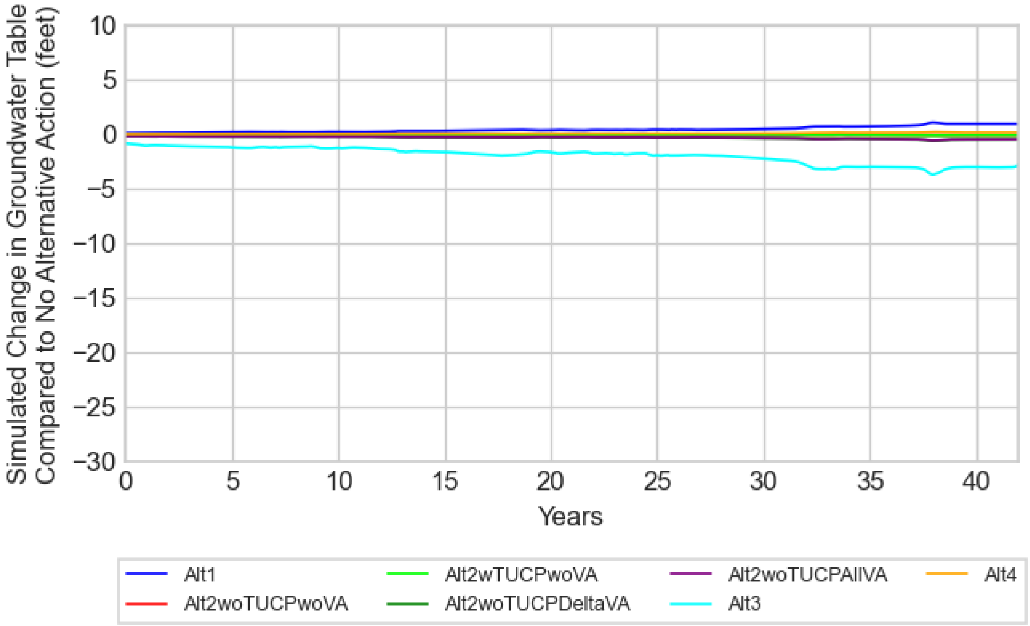


Figure I-79. Simulated Change in Groundwater Table Elevation at Location SR17-B

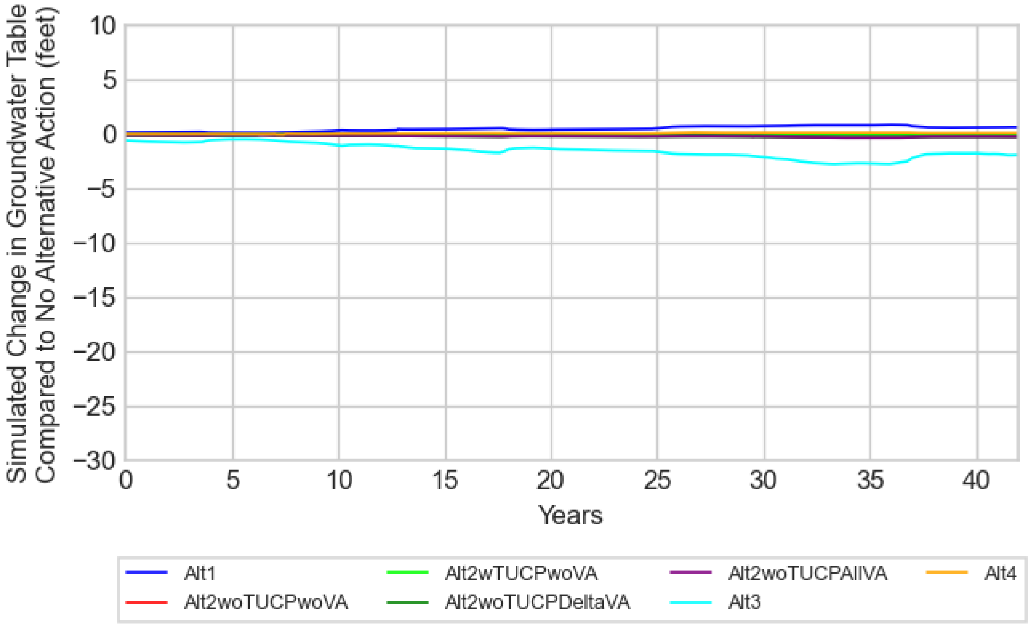


Figure I-80. Simulated Change in Groundwater Table Elevation at Location SR17-C

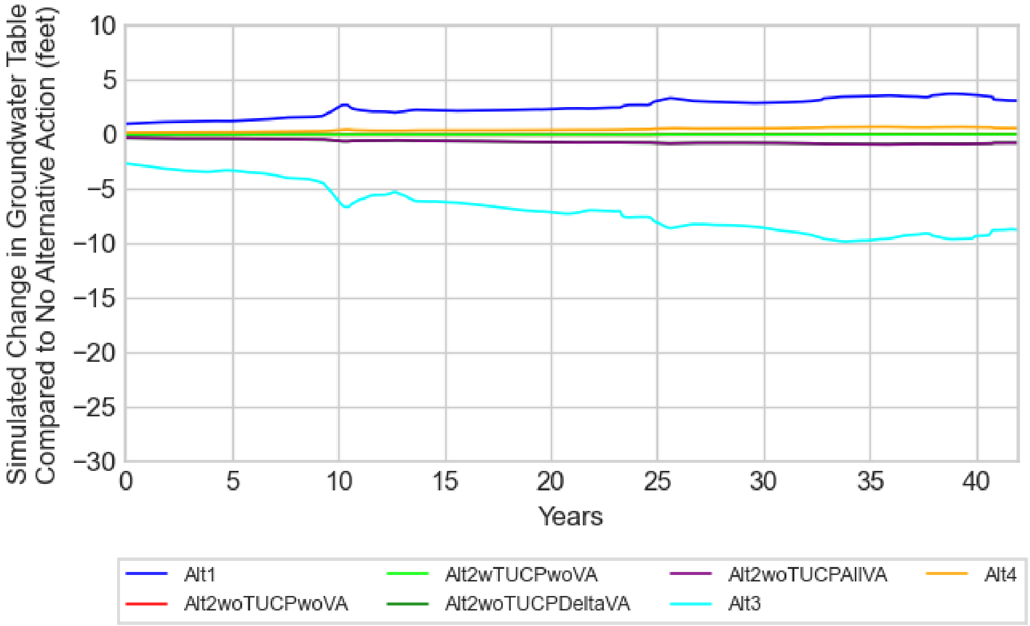


Figure I-81. Simulated Change in Groundwater Table Elevation at Location SR18-A

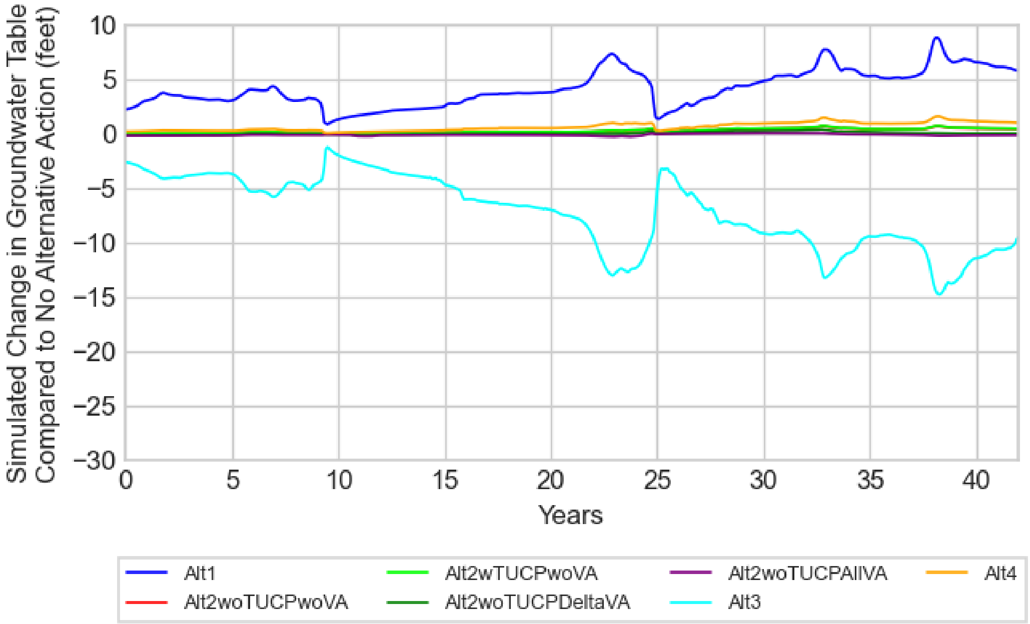


Figure I-82. Simulated Change in Groundwater Table Elevation at Location SR18-B

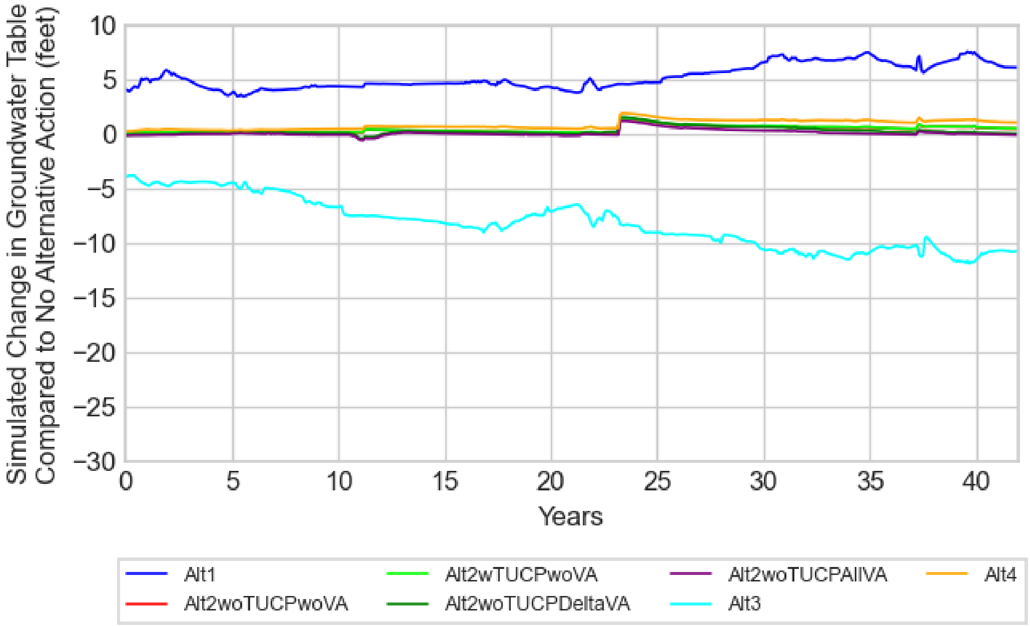


Figure I-83. Simulated Change in Groundwater Table Elevation at Location SR18-C

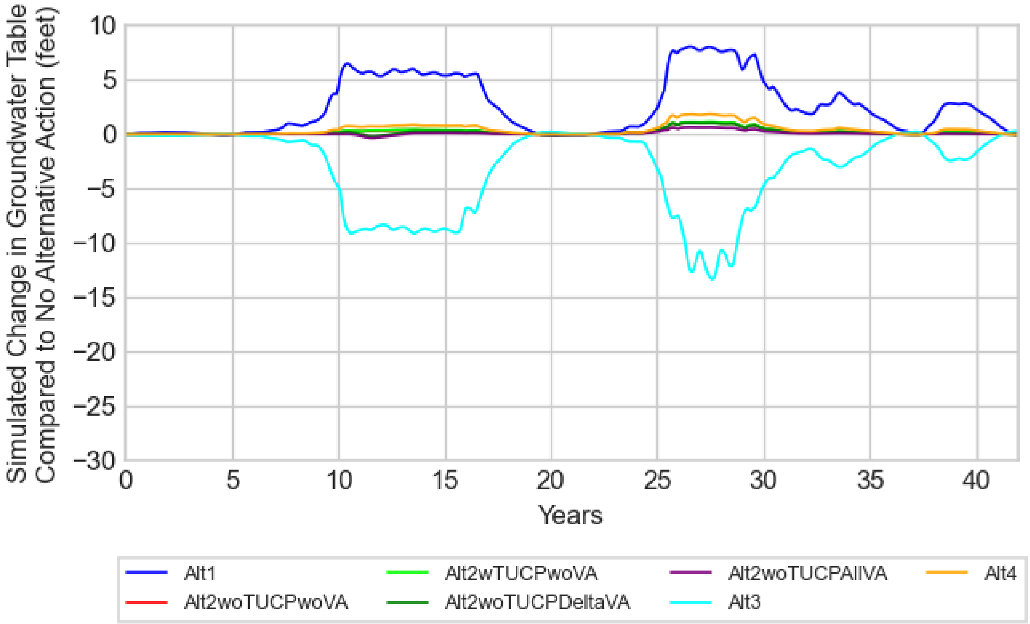


Figure I-84. Simulated Change in Groundwater Table Elevation at Location SR18-D

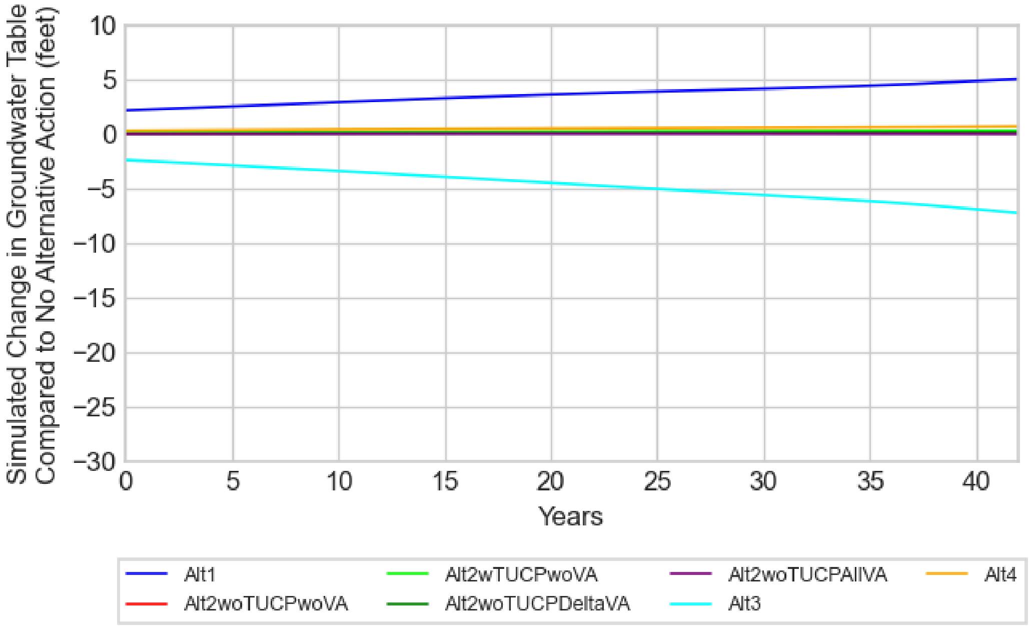


Figure I-85. Simulated Change in Groundwater Table Elevation at Location SR19-A

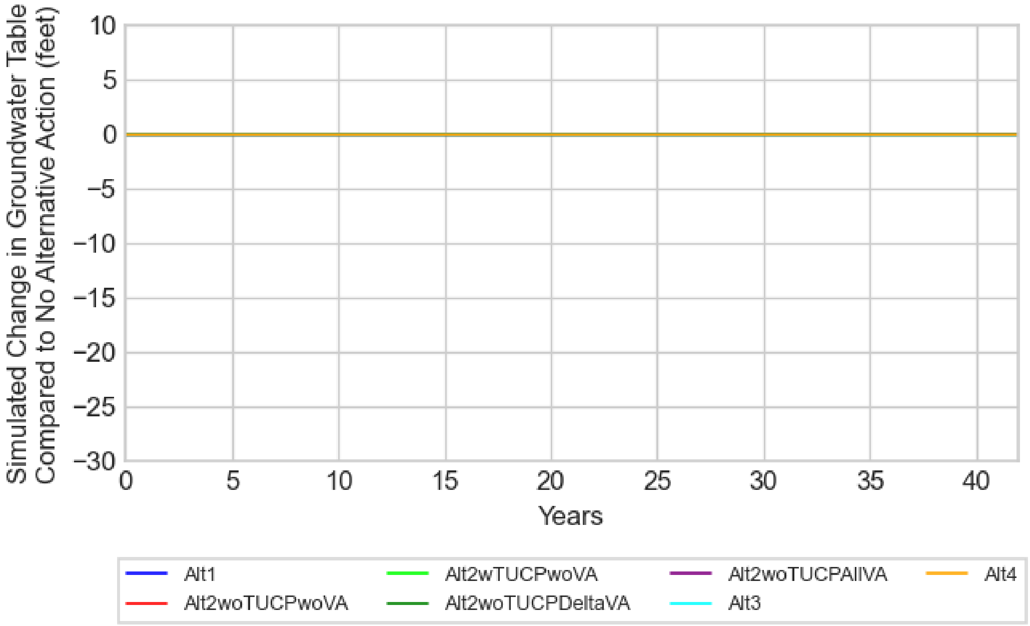


Figure I-86. Simulated Change in Groundwater Table Elevation at Location SR19-B

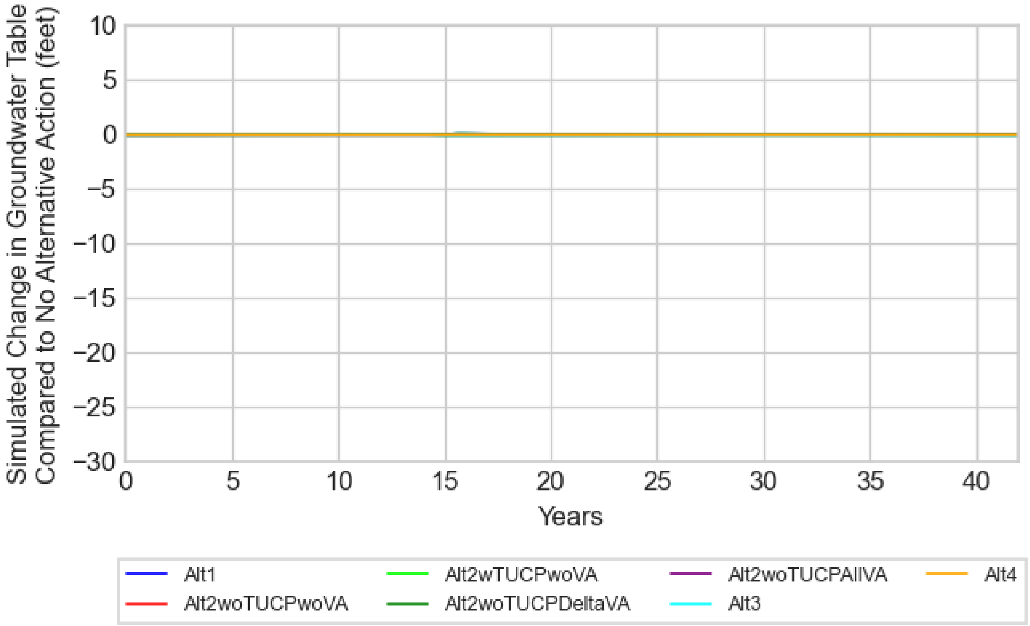


Figure I-87. Simulated Change in Groundwater Table Elevation at Location SR19-C

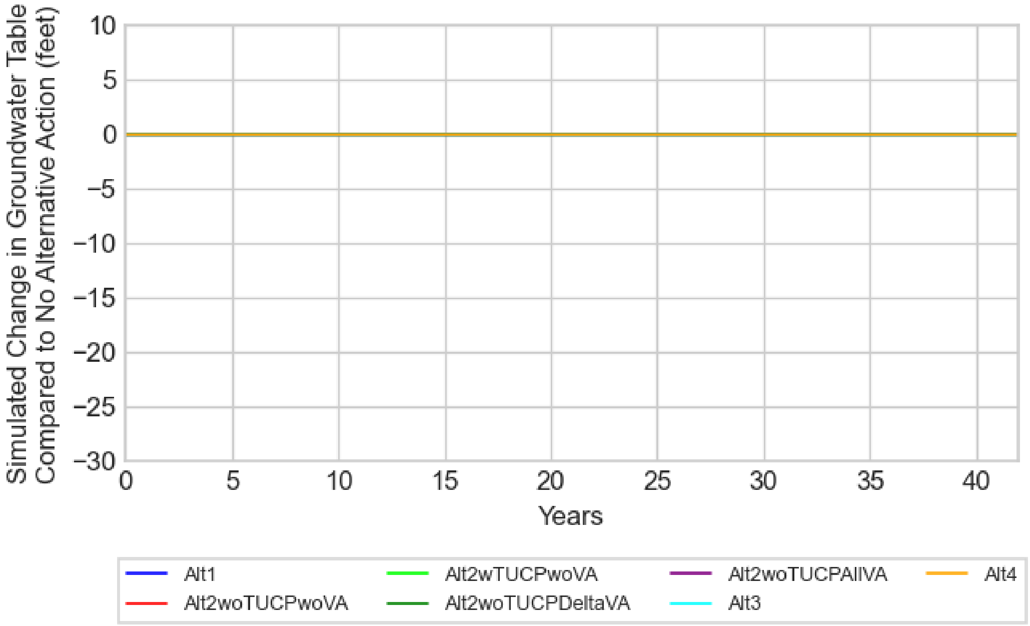


Figure I-88. Simulated Change in Groundwater Table Elevation at Location SR20-A

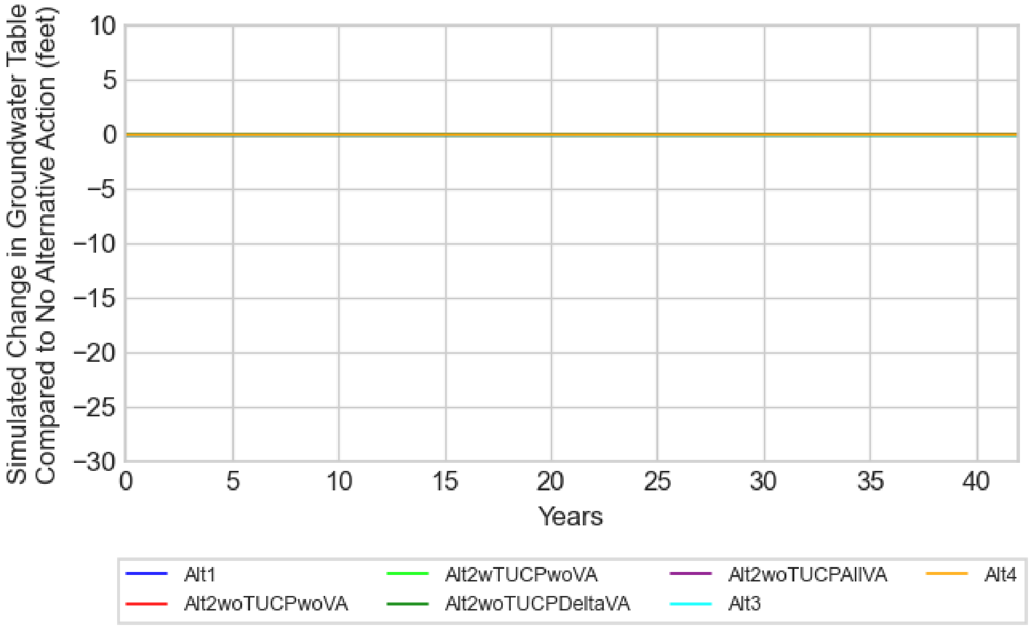


Figure I-89. Simulated Change in Groundwater Table Elevation at Location SR20-B

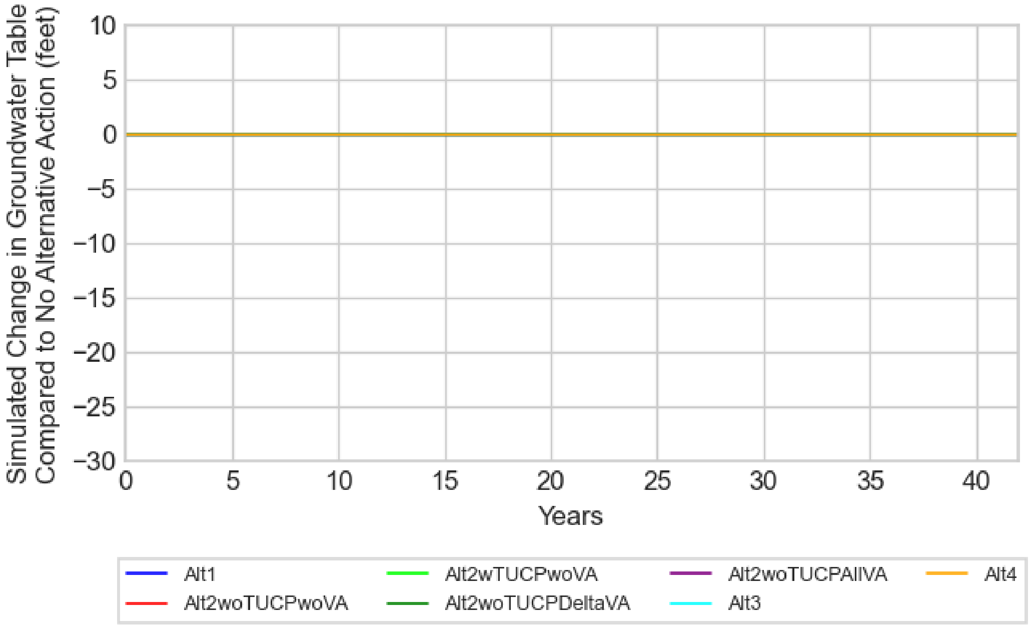


Figure I-90. Simulated Change in Groundwater Table Elevation at Location SR20-C

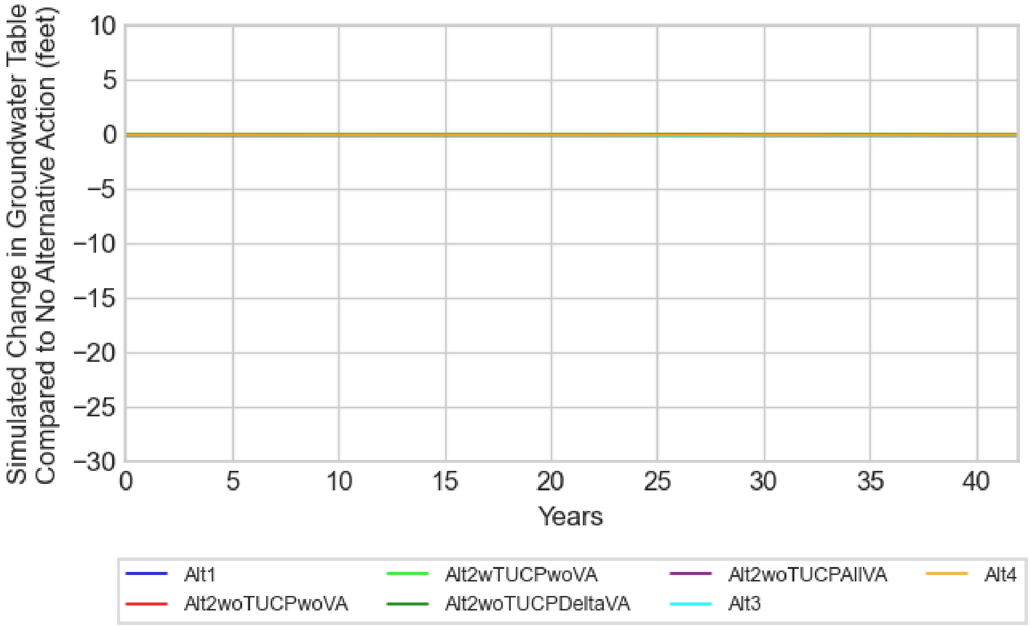


Figure I-91. Simulated Change in Groundwater Table Elevation at Location SR21-A

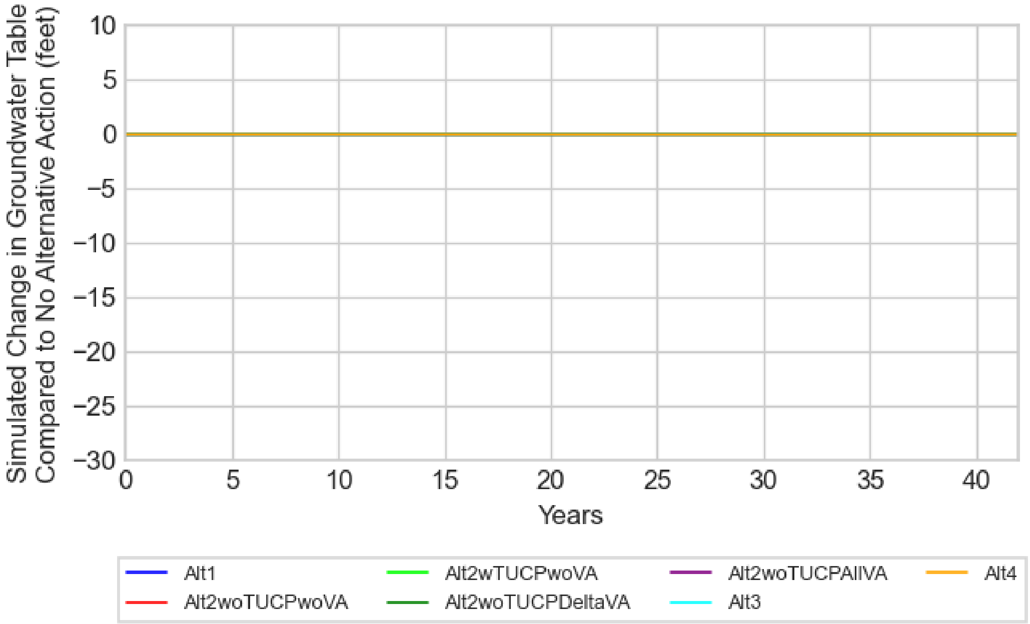


Figure I-92. Simulated Change in Groundwater Table Elevation at Location SR21-B

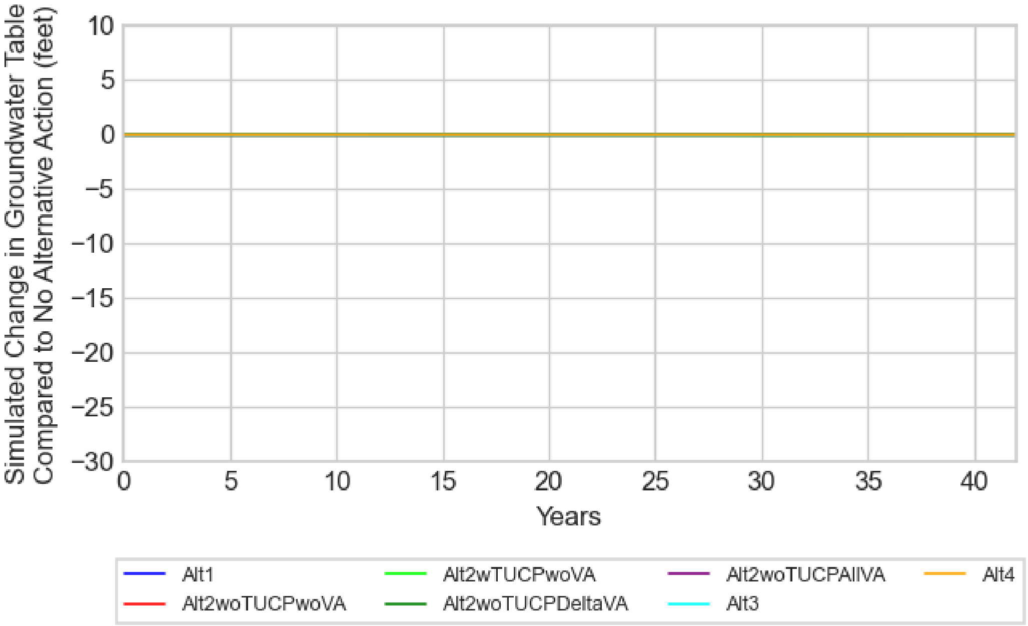


Figure I-93. Simulated Change in Groundwater Table Elevation at Location SR21-C

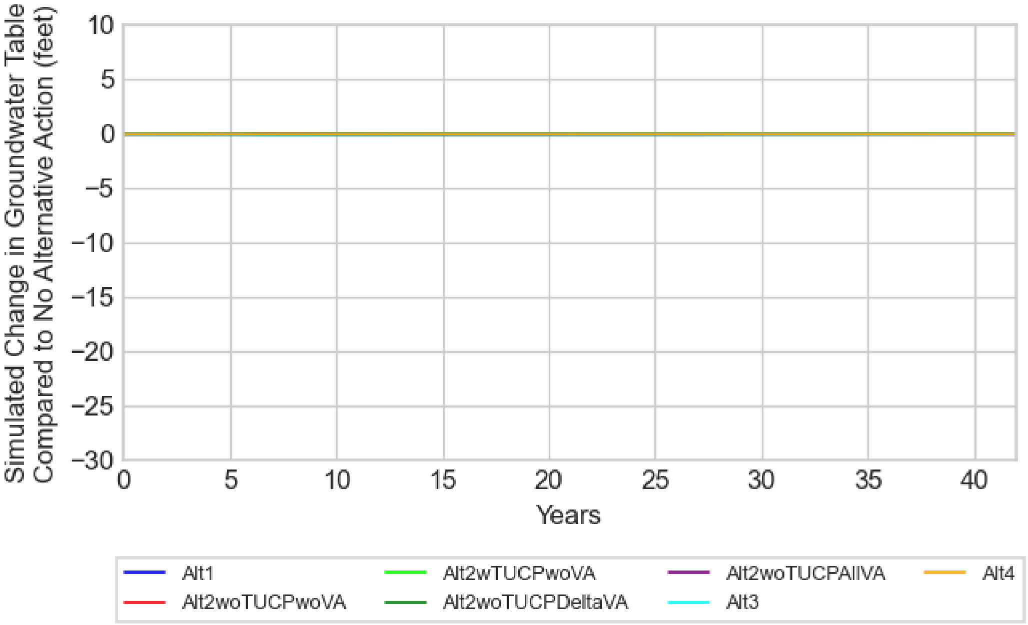


Figure I-94. Simulated Change in Groundwater Table Elevation at Location SR21-D

Figure I-95 through Figure I-99 show the average simulated change in groundwater table elevation for each of the five water year types defined by DWR. Table I-6 shows the range of the change in groundwater levels for Alternative 1 in comparison to the No Action Alternative.

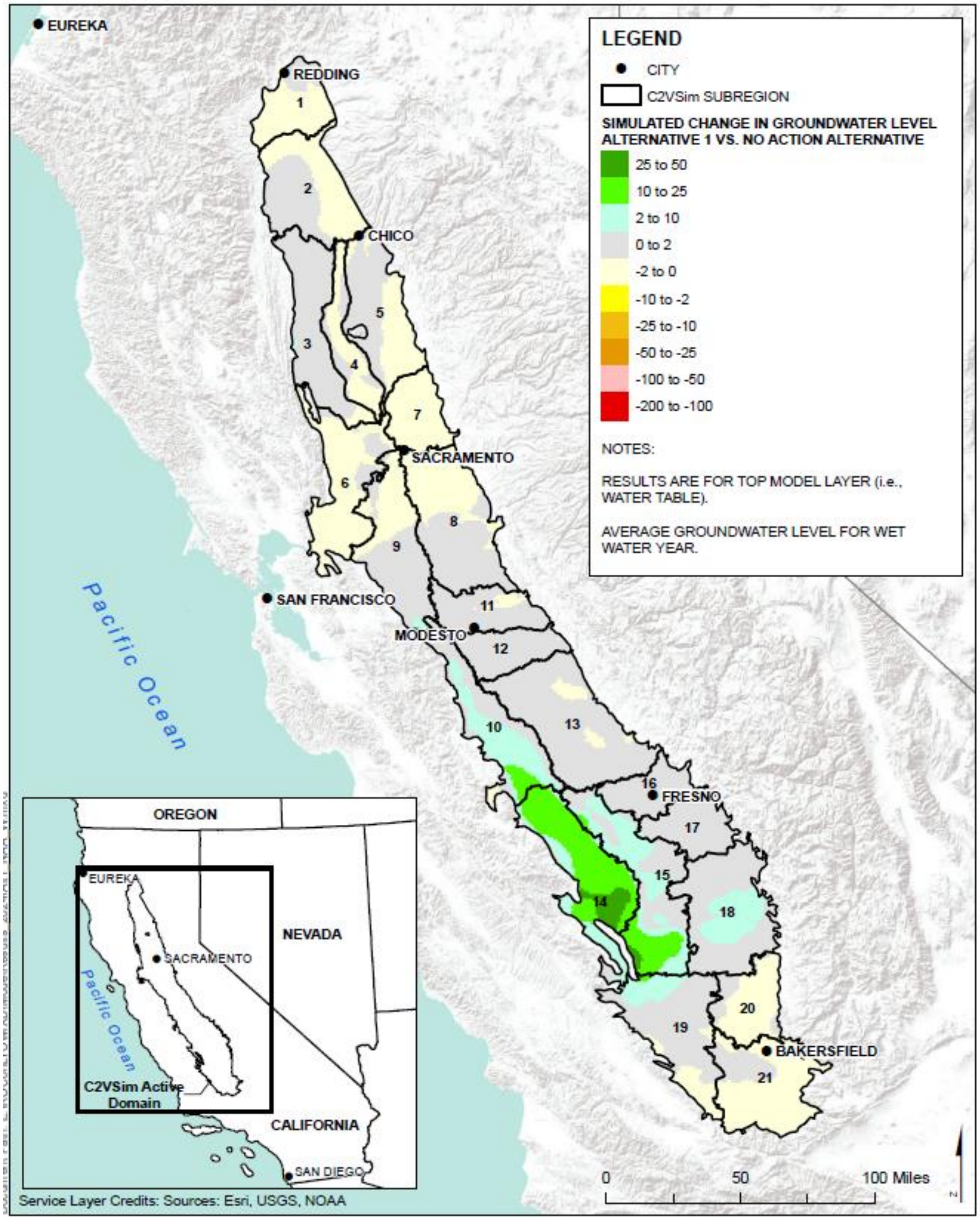


Figure I-95. Average Simulated Change in Groundwater Table Elevation for all Wet Water Years Alternative 1 Compared to the No Action Alternative

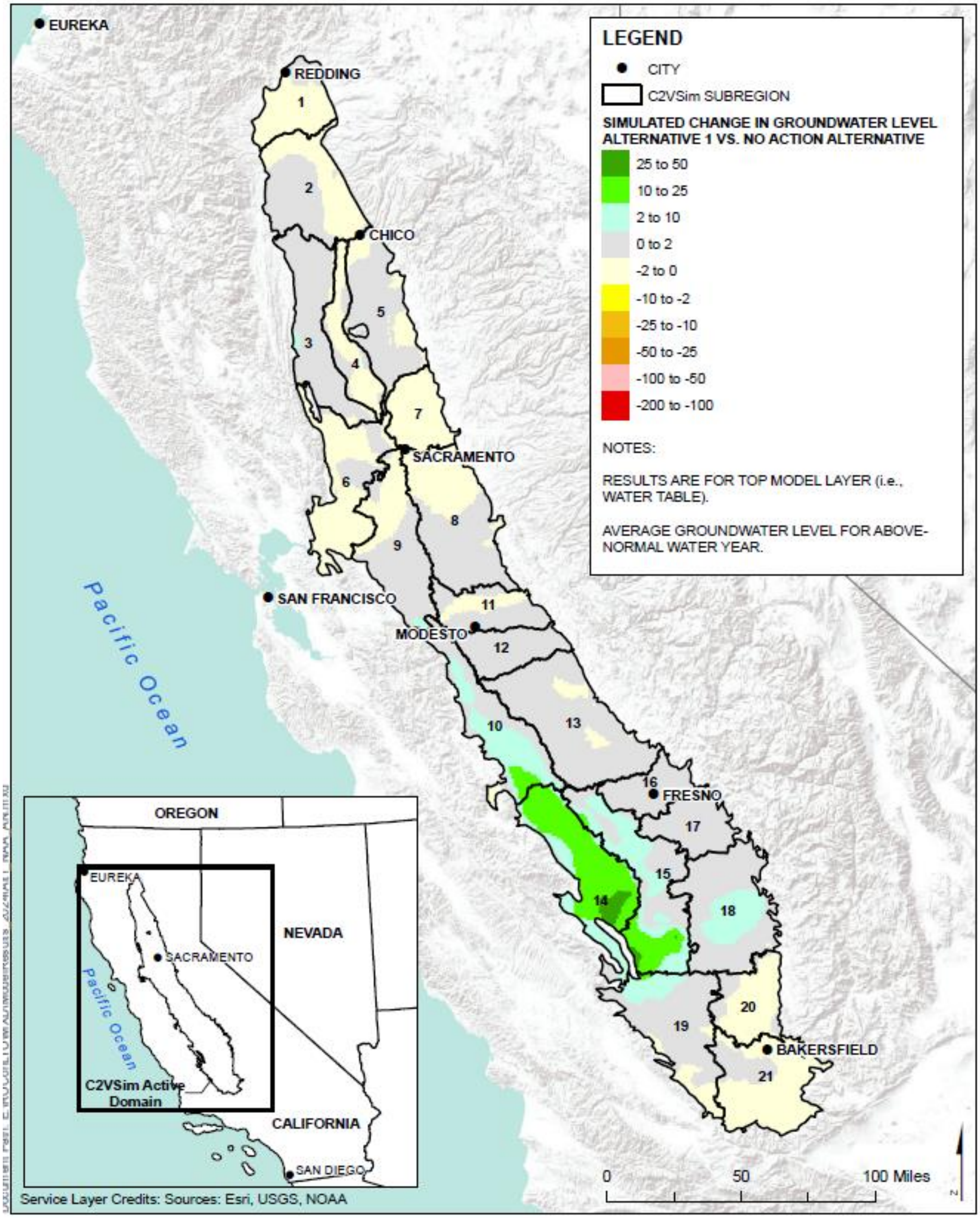


Figure I-96. Average Simulated Change in Groundwater Table Elevation for all Above Normal Water Years Alternative 1 Compared to the No Action Alternative

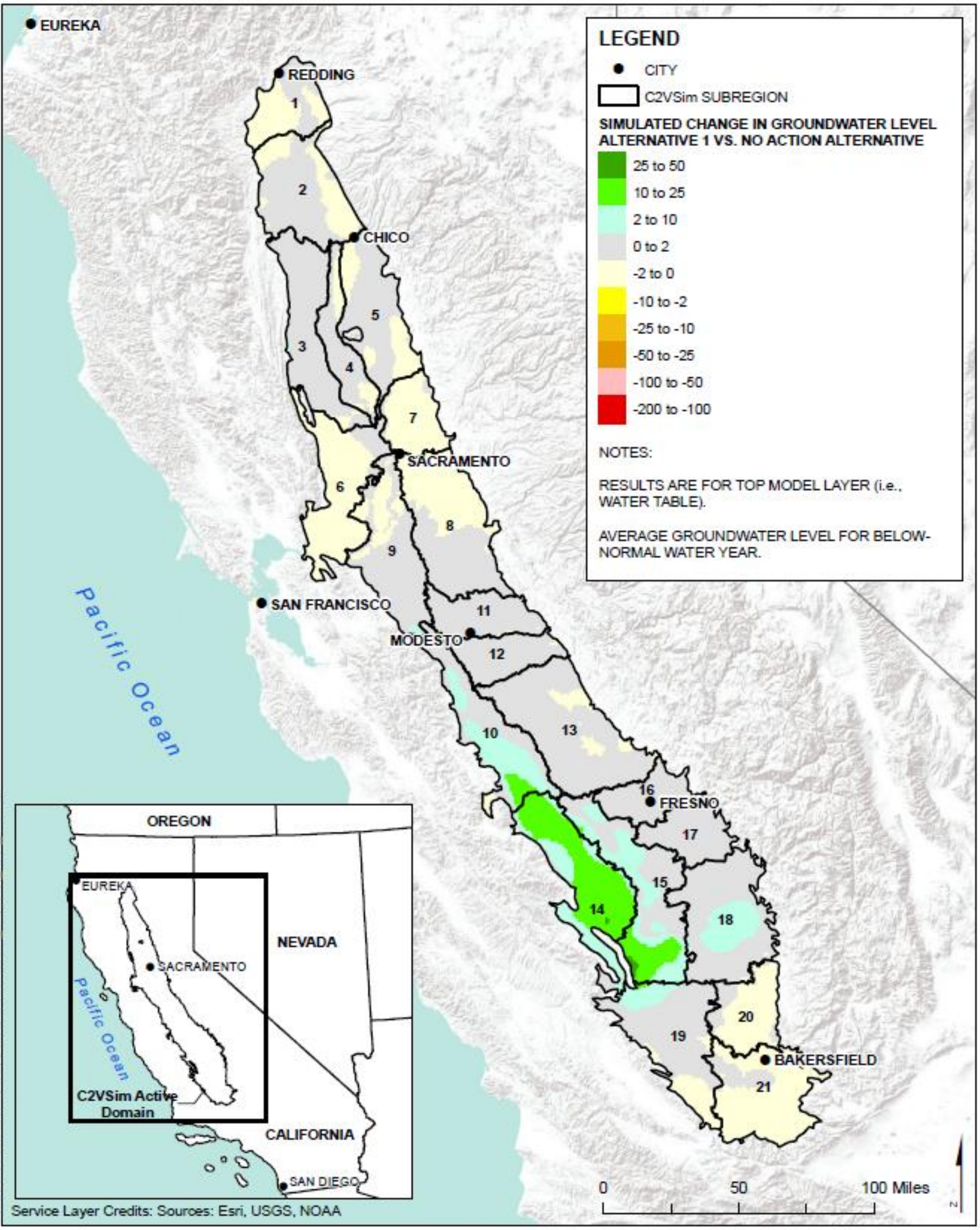
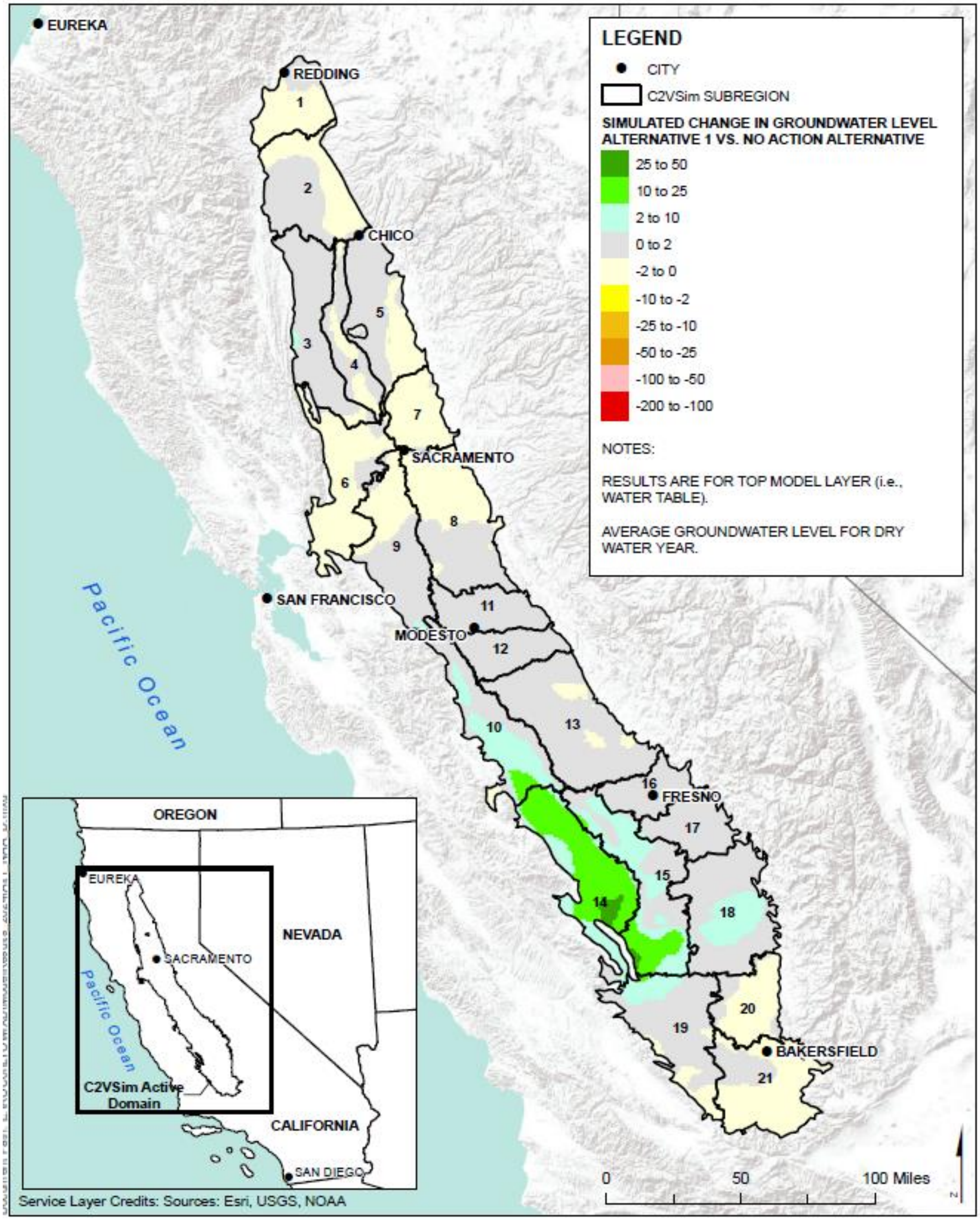


Figure I-97. Average Simulated Change in Groundwater Table Elevation for all Below Normal Water Years Alternative 1 Compared to the No Action Alternative



NOTES:

RESULTS ARE FOR TOP MODEL LAYER (i.e., WATER TABLE).

AVERAGE GROUNDWATER LEVEL FOR DRY WATER YEAR.

Service Layer Credits: Sources: Esri, USGS, NOAA

Figure I-98. Average Simulated Change in Groundwater Table Elevation for all Dry Water Years Alternative 1 Compared to the No Action Alternative

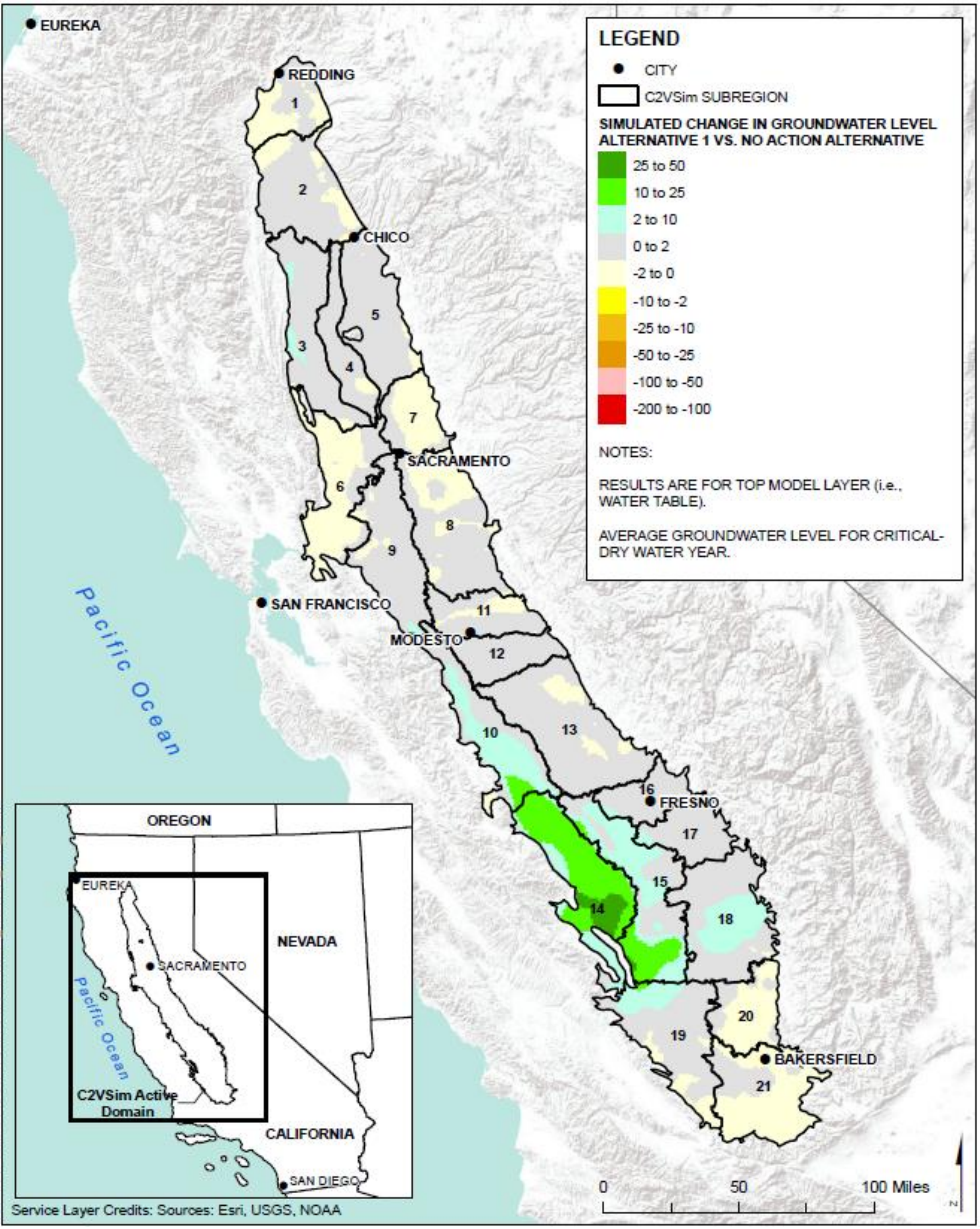


Figure I-99. Average Simulated Change in Groundwater Table Elevation for all Critical Water Years Alternative 1 Compared to the No Action Alternative

Table I-6. Simulated Change in Groundwater Table Elevation (feet) in the Central Valley for Alternative 1 Compared to the No Action Alternative for Each Water Year Type

Elevation	Wet	Above Normal	Below Normal	Dry	Critical
Average	1.2	1.2	1.0	1.1	1.3
Maximum	32.6	31.0	29.9	30.7	32.5
Minimum	-0.6	-0.6	-1.4	-0.9	-1.2

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Central Valley is not recorded and, therefore, unavailable. Therefore, any impact to local unknown wells cannot be determined but decreases in groundwater elevations may cause groundwater levels to fall below well screens.

Central Coast Region

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The C2VSimFG model does simulate pumping in this region. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Any increase in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels. Surface water supply deliveries are discussed in Appendix H.

As discussed in the *Central Coast Region* subsection under Section I.2.3.1, groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Central Valley is not recorded and, therefore, unavailable. Therefore, any impact to local unknown wells cannot be determined but decreases in groundwater elevations may cause groundwater levels to fall below well screens. Therefore, any impact to local unknown wells cannot be determined but decreases in groundwater elevations may cause groundwater levels to fall below well screens.

Southern California Region

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The C2VSimFG model does simulate pumping in this region. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Any increase in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels. Surface water supply deliveries are discussed in Appendix H.

As discussed in the *Southern California Region* subsection under Section I.2.3.1, groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Central Valley is not recorded and, therefore, unavailable. Therefore, any impact to local unknown wells cannot be determined but decreases in groundwater elevations may cause groundwater levels to fall below well screens.

I.2.3.4 Potential Changes in Land Subsidence

Trinity River

The area along the Trinity River is not known to be susceptible to subsidence and as was noted in the *Trinity River* subsection under Section I.2.3.1, groundwater pumping is not expected to increase in this region, suggesting that subsidence will not be a concern in this area. Additional information related to subsidence is available in Appendix W, *Geology and Soils Technical Appendix*.

Central Valley

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. In the Sacramento and San Joaquin Valleys, that reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Given that groundwater levels are generally expected to increase or remain unchanged due to Alternative 1, it is unlikely that Alternative 1 would cause additional subsidence compared with the No Action Alternative. Additional information related to subsidence is available in Appendix W.

Central Coast Region

The Central Coast Region is not known to be susceptible to subsidence. However, increases in groundwater pumping may induce subsidence in areas where subsidence has not been recorded previous if groundwater levels and soil conditions allow. Additional information related to subsidence is available in Appendix W.

Southern California Region

The Southern California region is not known to be susceptible to subsidence. However, increases in groundwater pumping may induce subsidence in areas where subsidence has not been recorded previously if groundwater levels and soil conditions allow. Additional information related to subsidence is available in Appendix W.

I.2.3.5 Potential Changes in Groundwater Quality

Trinity River

Given that there is likely to be little change to groundwater conditions in this region either through pumping or groundwater-surface water interaction flow, there will similarly be little change to groundwater quality in the region.

Central Valley

Groundwater quality in the Central Valley has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

Central Coast Region

Similar to the Central Valley, groundwater quality in the Central Coast Region has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

Southern California Region

Similar to the Central Valley, groundwater quality has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

I.2.4 Alternative 2

Alternative 2 consists of four phases that are considered in the assessment of Alternative 2 to bracket the range of potential impacts. Alternative 2, Multi-Agency Consensus, provides for governance decisions that would be made at certain junctures over time, which are described as four different "phases". Implementation of Alternative 2 may include the Alternative 2 Without Temporary Urgency Change Petition (TUCP) Delta Voluntary Agreements (VA) phase, Alternative 2 Without TUCP Without VA phase, Alternative 2 Without TUCP Systemwide VA phase, or Alternative 2 With TUCP Without VA phase. The effect on groundwater conditions for each phase would differ. The four phases were all evaluated to present the maximum possible effects (adverse and beneficial) resulting from operations under any singular phase. This section presents tables with changes to groundwater conditions for all phases of Alternative 2 (best-case scenario) and the minimum potential water supply deliveries under all phases of Alternative 2 (worst-case)

I.2.4.1 Potential Changes in Groundwater Pumping

Trinity River

Operations in the Trinity River would remain similar to those under the No Action Alternative. The Trinity River Restoration Program Record of Decision controls Trinity River operations, and Reclamation would continue to release flows into the Trinity River as it does under the No Action Alternative.

Central Valley

Table I-7 through Table I-10 show the simulated change in groundwater pumping in the Central Valley for all four phases of Alternative 2 compared to the No Action Alternative. Alternative 2 results in an average annual increase in groundwater pumping ranging from 19 TAF to 59 TAF, with a maximum single year increase in groundwater pumping ranging from 156 TAF to 226 TAF and a maximum single year decrease in groundwater pumping ranging from 78 TAF to 182 TAF. Groundwater pumping results for each of the C2VSim subregions is provided in Attachment I-1. As noted in Section I.2.1, *Methods and Tools*, the C2VSimFG model does not simulate limitations to groundwater pumping that may be imposed as part of a local GSP. Therefore, the simulated groundwater pumping values simulated by C2VSimFG may overestimate the amount of groundwater pumping in certain areas.

Table I-7. Simulated Change in Groundwater Pumping in the Central Valley for Alternative 2 Without TUCP Without VA Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v1 minus NAA (TAF)	Alt2v1 minus NAA (% Difference)
1	W, W	-4	0.0%
2	W, W	-45	-0.4%
3	C, C	60	0.4%
4	C, C	4	0.0%
5	AN, W	-1	0.0%
6	BN, AN	21	0.2%
7	AN, W	-7	-0.1%
8	D, D	15	0.1%
9	W, W	7	0.1%
10	W, W	-2	0.0%
11	W, AN	-17	-0.1%
12	D, D	35	0.3%
13	W, W	25	0.2%
14	D, D	66	0.5%
15	C, C	200	1.3%
16	D, C	39	0.2%
17	C, C	-44	-0.3%
18	C, C	76	0.5%
19	C, C	16	0.1%
20	AN, W	-171	-1.4%
21	C, C	214	1.5%
22	W, W	51	0.5%
23	W, W	-1	0.0%
24	W, W	-51	-0.4%
25	W, W	4	0.0%
26	W, AN	-7	-0.1%
27	AN, AN	-34	-0.3%
28	D, D	47	0.3%
29	D, D	26	0.2%
30	AN, BN	15	0.1%
31	BN, D	6	0.0%
32	AN, W	-23	-0.2%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v1 minus NAA (TAF)	Alt2v1 minus NAA (% Difference)
33	W, W	-9	-0.1%
34	D, C	-6	0.0%
35	C, C	111	0.7%
36	D, BN	30	0.2%
37	BN, AN	26	0.2%
38	W, W	1	0.0%
39	BN, D	-83	-0.6%
40	D, C	120	0.7%
41	C, C	84	0.4%
42	C, C	-10	-0.1%
Average		**19**	**0.1%**
Maximum		**214**	**1.5%**
Minimum		**-171**	**-1.4%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Table I-8. Simulated Change in Groundwater Pumping in the Central Valley for Alternative 2 With TUCP Without VA Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v1wTUCP minus NAA (TAF)	Alt2v1WTUCP minus NAA (% Difference)
1	W, W	-4	0.0%
2	W, W	-45	-0.4%
3	C, C	60	0.4%
4	C, C	98	0.5%
5	AN, W	-5	0.0%
6	BN, AN	-3	0.0%
7	AN, W	-14	-0.1%
8	D, D	15	0.1%
9	W, W	8	0.1%
10	W, W	-1	0.0%
11	W, AN	-16	-0.1%
12	D, D	36	0.3%
13	W, W	26	0.2%
14	D, D	66	0.5%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v1wTUCP minus NAA (TAF)	Alt2v1WTUCP minus NAA (% Difference)
15	C, C	202	1.3%
16	D, C	38	0.2%
17	C, C	3	0.0%
18	C, C	99	0.6%
19	C, C	15	0.1%
20	AN, W	-182	-1.5%
21	C, C	196	1.3%
22	W, W	47	0.4%
23	W, W	-2	0.0%
24	W, W	-50	-0.4%
25	W, W	2	0.0%
26	W, AN	-7	-0.1%
27	AN, AN	-35	-0.3%
28	D, D	45	0.3%
29	D, D	25	0.2%
30	AN, BN	17	0.1%
31	BN, D	16	0.1%
32	AN, W	-20	-0.2%
33	W, W	-11	-0.1%
34	D, C	-7	0.0%
35	C, C	112	0.7%
36	D, BN	26	0.2%
37	BN, AN	27	0.2%
38	W, W	2	0.0%
39	BN, D	-83	-0.6%
40	D, C	123	0.7%
41	C, C	120	0.6%
42	C, C	-3	0.0%
Average		**22**	**0.1%**
Maximum		**202**	**1.3%**
Minimum		**-182**	**-1.5%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Table I-9. Simulated Change in Groundwater Pumping in the Central Valley for Alternative 2 Without TUCP Delta VA Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v2 minus NAA (TAF)	Alt2v2 minus NAA (% Diff)
1	W, W	4	0.0%
2	W, W	24	0.2%
3	C, C	58	0.4%
4	C, C	11	0.1%
5	AN, W	77	0.6%
6	BN, AN	48	0.4%
7	AN, W	76	0.7%
8	D, D	78	0.6%
9	W, W	14	0.1%
10	W, W	-5	-0.1%
11	W, AN	-9	-0.1%
12	D, D	85	0.6%
13	W, W	21	0.2%
14	D, D	99	0.7%
15	C, C	108	0.7%
16	D, C	75	0.5%
17	C, C	-136	-0.8%
18	C, C	57	0.3%
19	C, C	-94	-0.6%
20	AN, W	-77	-0.6%
21	C, C	156	1.1%
22	W, W	42	0.4%
23	W, W	-1	0.0%
24	W, W	-49	-0.4%
25	W, W	9	0.1%
26	W, AN	-5	0.0%
27	AN, AN	85	0.7%
28	D, D	96	0.7%
29	D, D	76	0.5%
30	AN, BN	101	0.8%
31	BN, D	96	0.7%
32	AN, W	48	0.5%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v2 minus NAA (TAF)	Alt2v2 minus NAA (% Diff)
33	W, W	-2	0.0%
34	D, C	52	0.3%
35	C, C	151	1.0%
36	D, BN	82	0.5%
37	BN, AN	80	0.6%
38	W, W	-5	0.0%
39	BN, D	-34	-0.2%
40	D, C	143	0.9%
41	C, C	79	0.4%
42	C, C	-43	-0.2%
Average		**40**	**0.3%**
Maximum		**156**	**1.1%**
Minimum		**-136**	**-0.8%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Table I-10. Simulated Change in Groundwater Pumping in the Central Valley for Alternative 2 Without TUCP Systemwide VA Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v3 minus NAA (TAF)	Alt2v3 minus NAA (% Difference)
1	W, W	10	0.1%
2	W, W	36	0.3%
3	C, C	57	0.4%
4	C, C	18	0.1%
5	AN, W	93	0.8%
6	BN, AN	103	0.9%
7	AN, W	96	0.9%
8	D, D	114	0.8%
9	W, W	20	0.2%
10	W, W	-4	0.0%
11	W, AN	-8	-0.1%
12	D, D	97	0.7%
13	W, W	22	0.2%
14	D, D	121	0.9%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v3 minus NAA (TAF)	Alt2v3 minus NAA (% Difference)
15	C, C	214	1.4%
16	D, C	63	0.4%
17	C, C	-52	-0.3%
18	C, C	96	0.6%
19	C, C	-42	-0.2%
20	AN, W	-78	-0.7%
21	C, C	226	1.5%
22	W, W	53	0.5%
23	W, W	2	0.0%
24	W, W	-51	-0.4%
25	W, W	8	0.1%
26	W, AN	1	0.0%
27	AN, AN	98	0.8%
28	D, D	122	0.9%
29	D, D	89	0.6%
30	AN, BN	103	0.8%
31	BN, D	123	0.9%
32	AN, W	70	0.7%
33	W, W	5	0.0%
34	D, C	65	0.4%
35	C, C	160	1.0%
36	D, BN	90	0.6%
37	BN, AN	90	0.7%
38	W, W	0	0.0%
39	BN, D	-23	-0.2%
40	D, C	197	1.2%
41	C, C	100	0.5%
42	C, C	-29	-0.2%
Average		**59**	**0.4%**
Maximum		**226**	**1.5%**
Minimum		**-78**	**-0.7%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Central Coast Region

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered by each of the alternatives. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP.

The groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water originally sourced by surface deliveries. Surface deliveries from the SWP are also in some Central Coast basins, an important support for satisfying salinity standards. In these basins, existing salinity levels in the underlying groundwater would limit its use to replace reduced surface water deliveries needed to support both sources of recharge. Without the ongoing support of groundwater recharge in this region, groundwater levels may decrease, eventually resulting in reduced groundwater production.

Southern California Region

Similar to the Central Coast Region, the C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Southern California Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP.

The groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water originally sourced by surface deliveries. Surface deliveries from the SWP are also in some Southern California basins, an important support for satisfying salinity standards. In these basins, existing salinity levels in the underlying groundwater would limit its use to replace reduced surface water deliveries needed to support both sources of recharge. Without the ongoing support of groundwater recharge in this region, groundwater levels may decrease, eventually resulting in reduced groundwater production.

I.2.4.2 Potential Changes in Groundwater-Surface Water Interaction Flow

Trinity River

Most usable groundwater in the Trinity River Region occurs in widely scattered alluvium-filled valleys, such as those immediately adjacent to the Trinity River. These valleys contain only small quantities of recoverable groundwater and therefore are not considered a major source. Given this hydrogeologic nature of this region, changes in surface water flow will likely result in little change to the groundwater-surface water interaction flow.

Central Valley

Table I-11 through Table I-14 show the simulated change in groundwater-surface water interaction flow in the Central Valley for all four phases of Alternative 2 compared to the No Action Alternative. Alternative 2 results in an average annual change in groundwater-surface water interaction flow ranging from 17 TAF to 69 TAF (flow to surface water from groundwater), with a maximum single year increase in flow from groundwater to surface water ranging from 126 TAF to 199 TAF and a maximum single year decrease in flow from surface water to groundwater ranging from 12 TAF to 16 TAF. Additional groundwater-surface water interaction flow results for each of the C2VSim subregions is provided in Attachment I-1.

Table I-11. Simulated Change in Groundwater-Surface Water Interaction Flow in the Central Valley for Alternative 2 Without TUCP Without VA Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v1 minus NAA (TAF)	Alt2v1 minus NAA (% Difference)
1	W, W	5	3.2%
2	W, W	-5	-7.1%
3	C, C	-2	-7.2%
4	C, C	41	5.0%
5	AN, W	11	0.4%
6	BN, AN	22	3.1%
7	AN, W	7	0.7%
8	D, D	0	-0.1%
9	W, W	22	4.0%
10	W, W	5	0.9%
11	W, AN	-16	-0.9%
12	D, D	7	0.6%
13	W, W	18	3.6%
14	D, D	10	1.4%
15	C, C	-3	-2.9%
16	D, C	53	7.9%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v1 minus NAA (TAF)	Alt2v1 minus NAA (% Difference)
17	C, C	12	2.2%
18	C, C	60	4.5%
19	C, C	126	8.1%
20	AN, W	25	1.3%
21	C, C	2	0.2%
22	W, W	46	2.1%
23	W, W	20	2.4%
24	W, W	8	1.4%
25	W, W	8	7.8%
26	W, AN	-12	-0.9%
27	AN, AN	21	3.3%
28	D, D	14	2.4%
29	D, D	17	26.4%
30	AN, BN	-1	-0.2%
31	BN, D	0	0.2%
32	AN, W	13	4.3%
33	W, W	-1	-0.6%
34	D, C	10	3.2%
35	C, C	-10	-3.9%
36	D, BN	28	4.3%
37	BN, AN	24	2.1%
38	W, W	3	0.3%
39	BN, D	-4	-4.1%
40	D, C	14	3.7%
41	C, C	61	6.5%
42	C, C	74	5.1%
Average		**17**	**2.3%**
Maximum		**126**	**26.4%**
Minimum		**-16**	**-7.2%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Table I-12. Simulated Change in Groundwater-Surface Water Interaction Flow in the Central Valley for Alternative 2 With TUCP Without VA Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v1wTUCP minus NAA (TAF)	Alt2v1WTUCP minus NAA (% Difference)
1	W, W	4	2.8%
2	W, W	-6	-8.5%
3	C, C	-3	-11.6%
4	C, C	33	4.0%
5	AN, W	65	2.1%
6	BN, AN	26	3.6%
7	AN, W	7	0.6%
8	D, D	1	0.3%
9	W, W	23	4.3%
10	W, W	6	1.0%
11	W, AN	-15	-0.9%
12	D, D	8	0.7%
13	W, W	18	3.7%
14	D, D	10	1.4%
15	C, C	-3	-2.7%
16	D, C	53	7.9%
17	C, C	5	1.0%
18	C, C	55	4.1%
19	C, C	130	8.3%
20	AN, W	15	0.8%
21	C, C	6	0.6%
22	W, W	48	2.3%
23	W, W	19	2.3%
24	W, W	7	1.2%
25	W, W	8	7.1%
26	W, AN	-13	-1.0%
27	AN, AN	20	3.2%
28	D, D	12	2.2%
29	D, D	16	25.3%
30	AN, BN	-1	-0.3%
31	BN, D	0	0.2%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v1wTUCP minus NAA (TAF)	Alt2v1WTUCP minus NAA (% Difference)
32	AN, W	14	4.6%
33	W, W	-2	-1.6%
34	D, C	10	3.1%
35	C, C	-9	-3.7%
36	D, BN	29	4.4%
37	BN, AN	24	2.1%
38	W, W	3	0.3%
39	BN, D	-4	-4.5%
40	D, C	14	3.7%
41	C, C	44	4.7%
42	C, C	95	6.5%
Average		**18**	**2.0%**
Maximum		**130**	**25.3%**
Minimum		**-15**	**-11.6%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Table I-13. Simulated Change in Groundwater-Surface Water Interaction Flow in the Central Valley for Alternative 2 Without TUCP Delta VA Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v2 - NAA (TAF)	Alt2v2 - NAA (% Diff)
1	W, W	19	12.6%
2	W, W	12	16.4%
3	C, C	19	65.9%
4	C, C	64	7.7%
5	AN, W	35	1.1%
6	BN, AN	23	3.2%
7	AN, W	44	4.1%
8	D, D	29	18.5%
9	W, W	40	7.5%
10	W, W	30	5.1%
11	W, AN	5	0.3%
12	D, D	44	4.1%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v2 - NAA (TAF)	Alt2v2 - NAA (% Diff)
13	W, W	19	3.8%
14	D, D	30	4.4%
15	C, C	09	0.1%
16	D, C	71	10.6%
17	C, C	3	0.6%
18	C, C	61	4.5%
19	C, C	153	9.8%
20	AN, W	15	0.8%
21	C, C	22	2.3%
22	W, W	44	2.0%
23	W, W	20	2.3%
24	W, W	14	2.5%
25	W, W	16	15.2%
26	W, AN	-9	-0.7%
27	AN, AN	18	2.9%
28	D, D	28	5.0%
29	D, D	35	56.4%
30	AN, BN	-12	-4.2%
31	BN, D	12	13.3%
32	AN, W	31	10.3%
33	W, W	29	20.5%
34	D, C	24	7.6%
35	C, C	5	2.0%
36	D, BN	60	9.2%
37	BN, AN	28	2.5%
38	W, W	39	4.4%
39	BN, D	20	21.1%
40	D, C	55	14.3%
41	C, C	52	5.6%
42	C, C	80	5.4%
Average		**32**	**9.1%**
Maximum		**153**	**65.9%**
Minimum		**-12**	**-4.2%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Table I-14. Simulated Change in Groundwater-Surface Water Interaction Flow in the Central Valley for Alternative 2 Without TUCP Systemwide VA Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v3 minus NAA (TAF)	Alt2v3 minus NAA (% Difference)
1	W, W	54	35.3%
2	W, W	43	58.7%
3	C, C	49	170.8%
4	C, C	83	10.1%
5	AN, W	57	1.9%
6	BN, AN	79	10.9%
7	AN, W	90	8.4%
8	D, D	79	50.3%
9	W, W	86	16.0%
10	W, W	49	8.4%
11	W, AN	21	1.2%
12	D, D	72	6.8%
13	W, W	46	9.2%
14	D, D	59	8.9%
15	C, C	62	51.6%
16	D, C	107	16.1%
17	C, C	59	11.2%
18	C, C	97	7.3%
19	C, C	199	12.7%
20	AN, W	42	2.2%
21	C, C	68	6.8%
22	W, W	80	3.8%
23	W, W	50	6.0%
24	W, W	38	6.7%
25	W, W	34	31.8%
26	W, AN	9	0.7%
27	AN, AN	50	8.0%
28	D, D	73	13.1%
29	D, D	104	164.6%
30	AN, BN	37	13.2%
31	BN, D	78	82.8%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt2v3 minus NAA (TAF)	Alt2v3 minus NAA (% Difference)
32	AN, W	84	28.4%
33	W, W	71	50.2%
34	D, C	57	18.3%
35	C, C	66	26.2%
36	D, BN	102	15.6%
37	BN, AN	59	5.2%
38	W, W	79	9.0%
39	BN, D	51	53.6%
40	D, C	96	25.0%
41	C, C	88	9.4%
42	C, C	103	7.0%
Average		**69**	**25.8%**
Maximum		**199**	**170.8%**
Minimum		**9**	**0.7%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Central Coast Region

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered by each of the alternatives. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

Southern California Region

Similar to the Central Coast Region, the C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Southern California Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

I.2.4.3 Potential Changes in Groundwater Elevation

Trinity River

Given that there is likely to be little change to the volume of groundwater either through pumping or groundwater-surface water interaction flow, there will be little change to groundwater levels in the area.

Central Valley

The C2VSimFG groundwater model provides simulated groundwater level over the entire model simulation period for every "node" in the model (nodes cover all subregions noted in Figure I-2). Figure I-3 through Figure I-94 show the simulated change in groundwater table elevation for node with the implementation of each of the phases of Alternative 2 in comparison to the No Action Alternative. The figures also show the simulation results for the other alternatives discussed in other sections.

The predicted change in groundwater table elevation for all phases of Alternative 2 as compared to the No Action Alternative spans a range from a decrease of 19.5 feet to an increase of 4.0 feet. However, note that this range of potential change captures the predicted groundwater table elevations across all 92 locations shown in the figures.

Figure I-100 through Figure I-119 show the average simulated change in groundwater table elevation for each of the phases of Alternative 2 for each of the five water year types defined by DWR. Table I-15 through Table I-18 shows the range of the change in groundwater levels for all phases of Alternative 2 in comparison to the No Action Alternative.

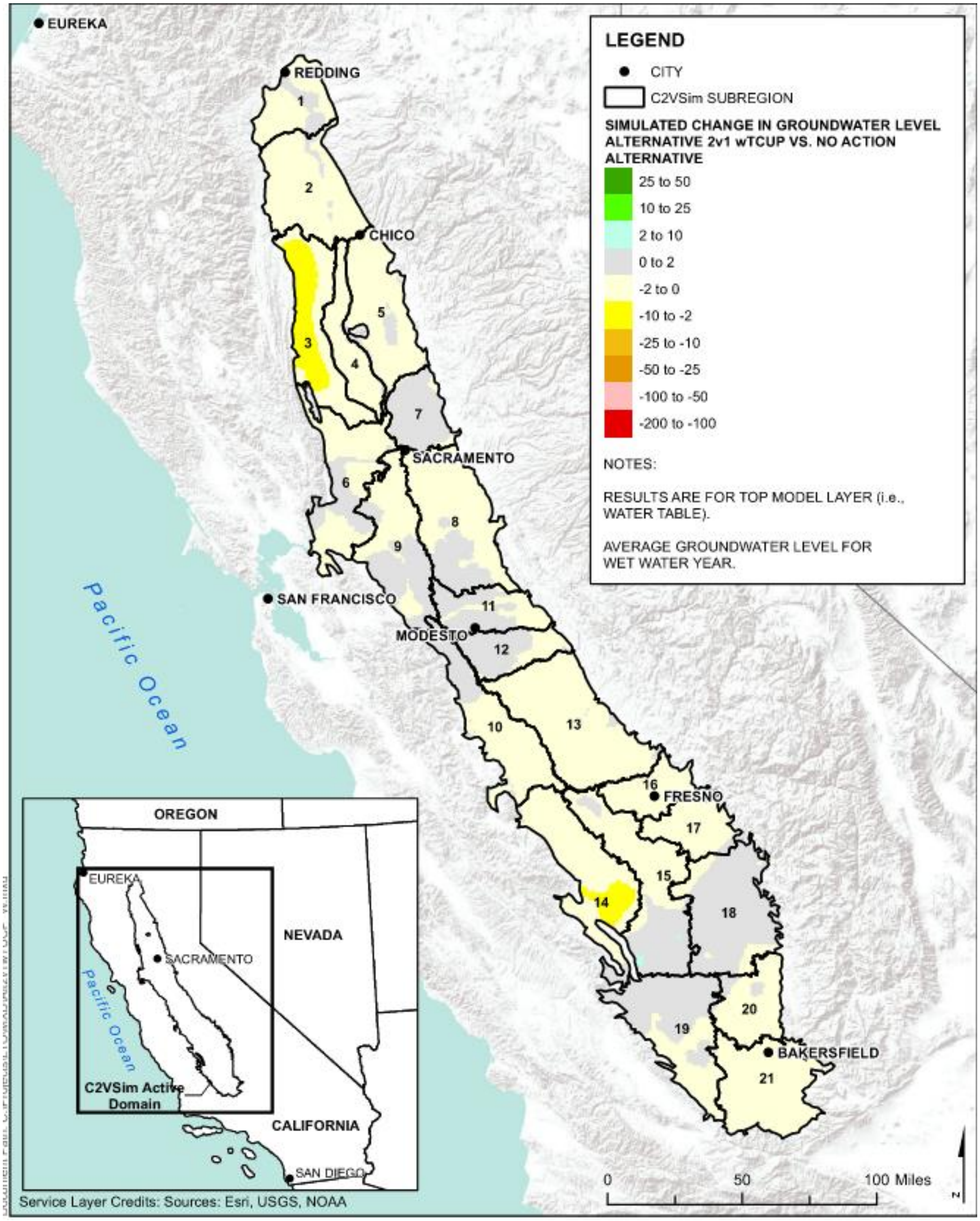


Figure I-100. Average Simulated Change in Groundwater Table Elevation for all Wet Water Years Alternative 2 With TUCP Without VA Compared to the No Action Alternative

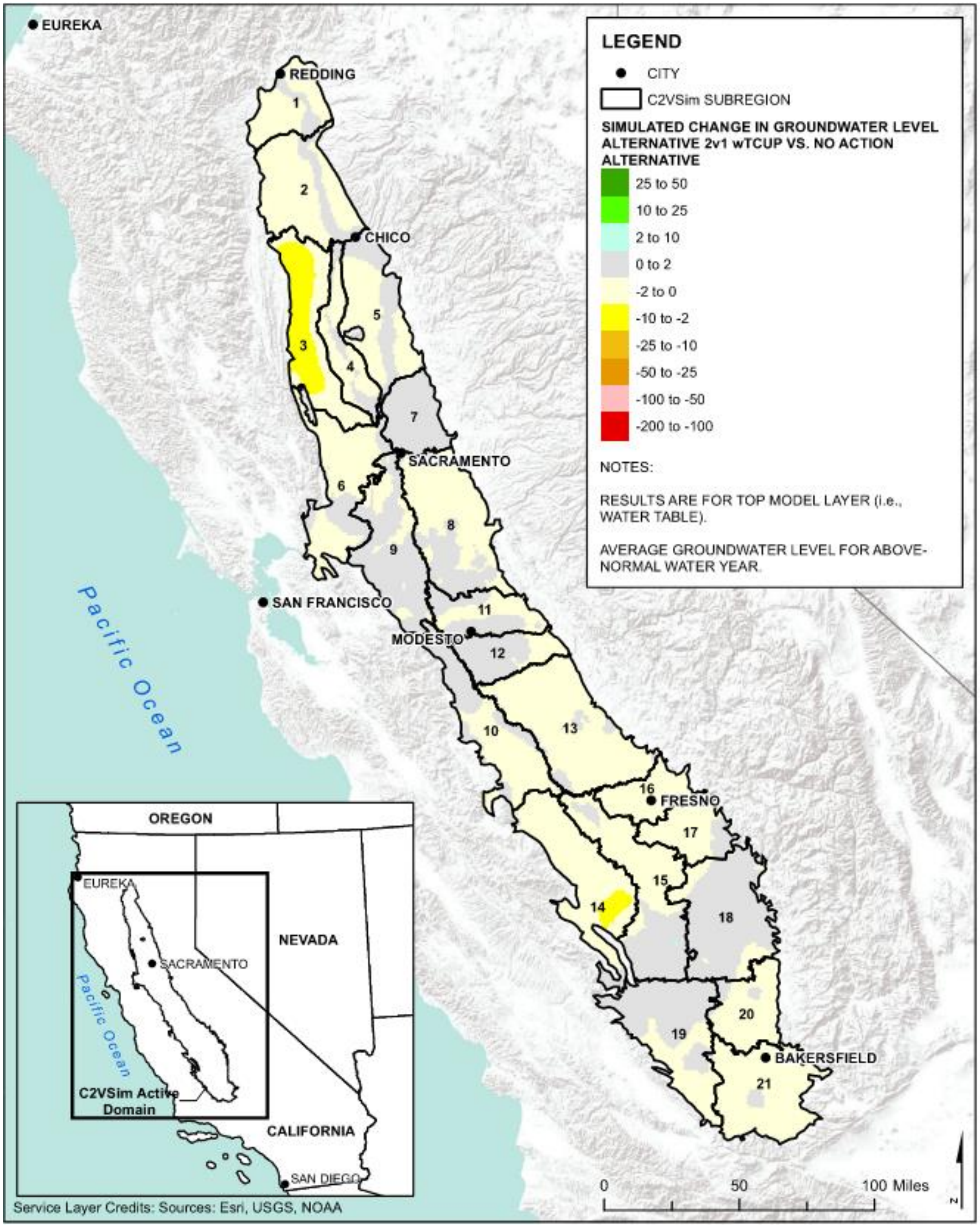


Figure I-101. Average Simulated Change in Groundwater Table Elevation for all Above Normal Water Years Alternative 2 With TUCP Without VA Compared to the No Action Alternative

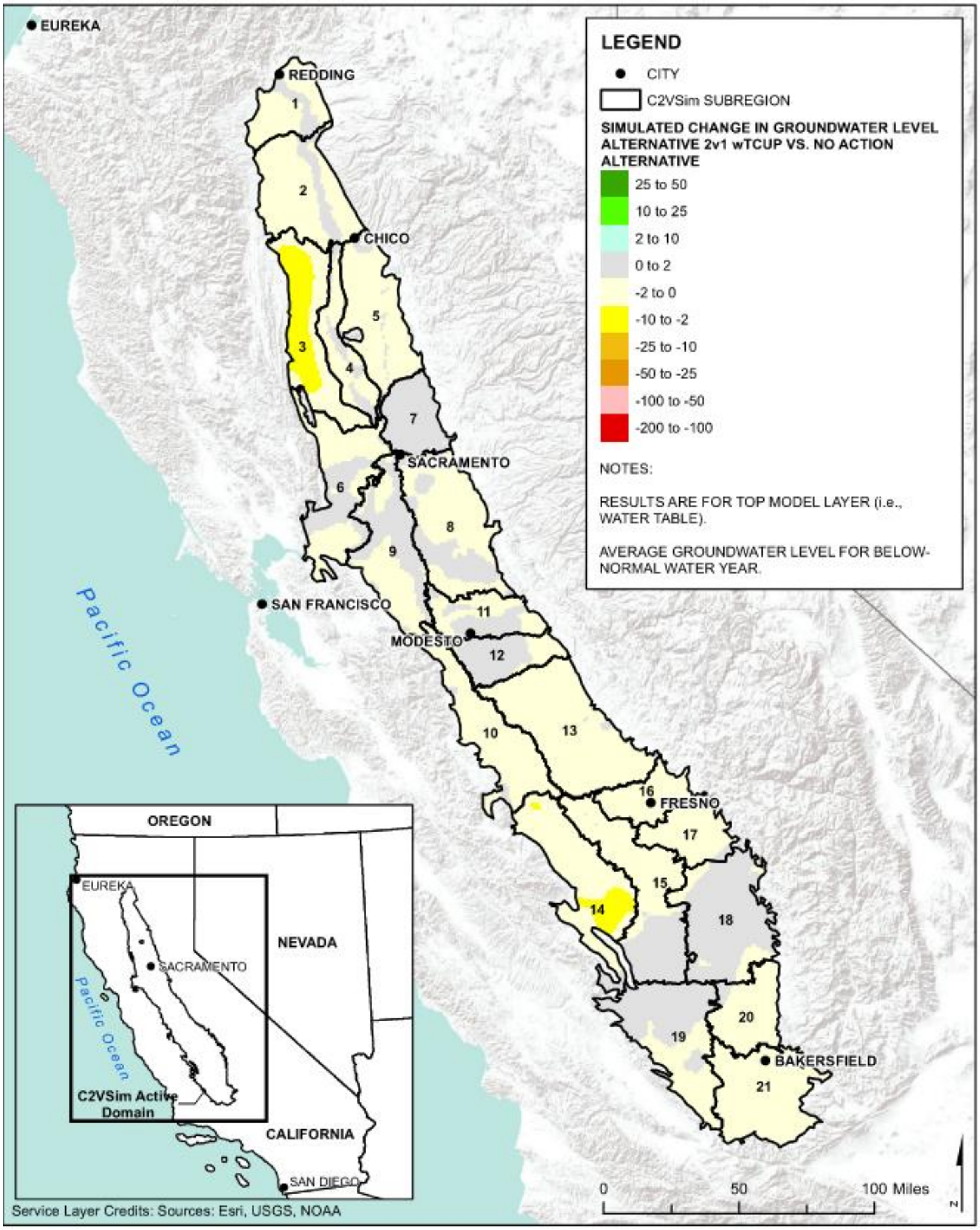


Figure I-102. Average Simulated Change in Groundwater Table Elevation for all Below Normal Water Years Alternative 2 With TUCP Without VA Compared to the No Action Alternative

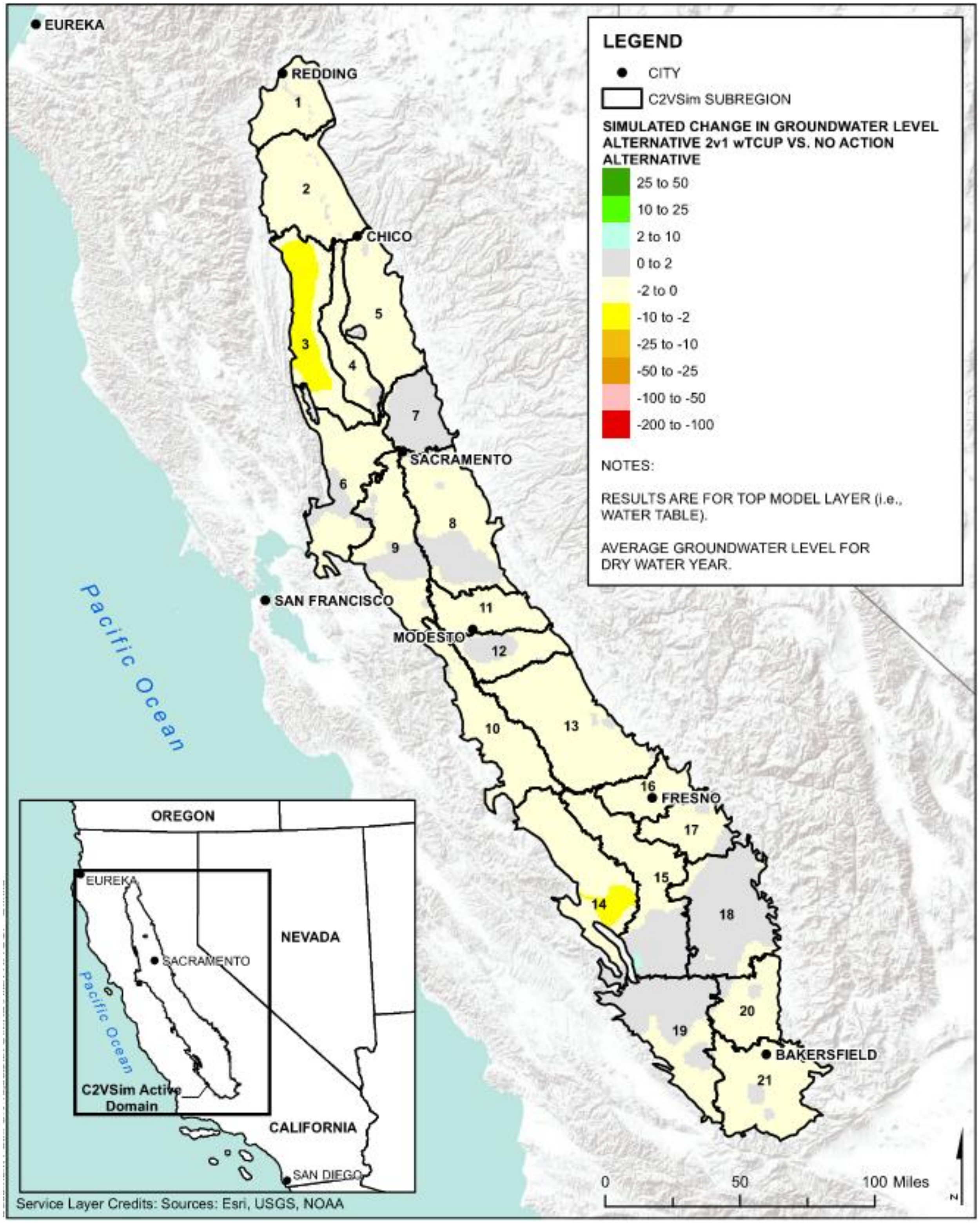


Figure I-103. Average Simulated Change in Groundwater Table Elevation for all Dry Water Years Alternative 2 With TUCP Without VA Compared to the No Action Alternative

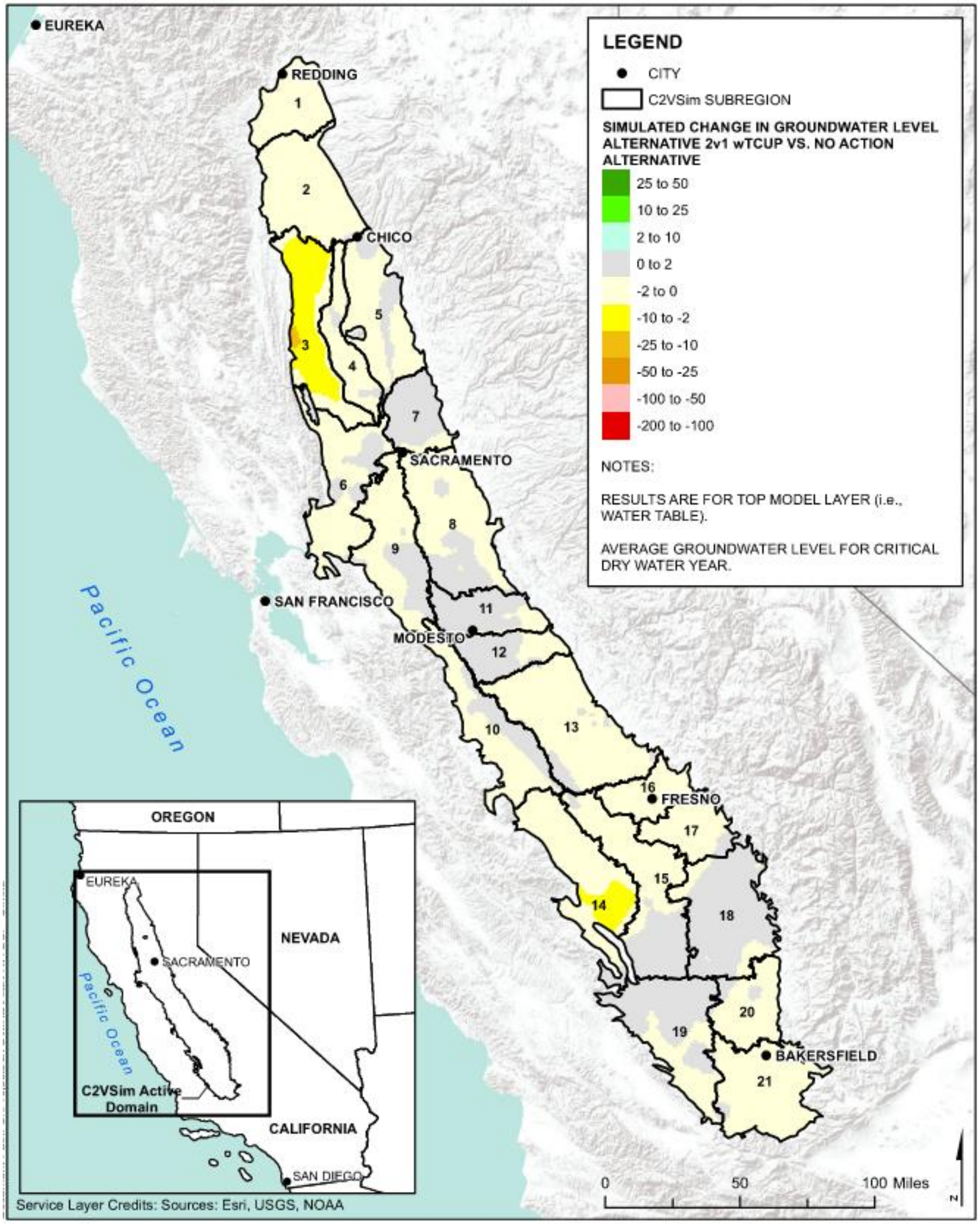


Figure I-104. Average Simulated Change in Groundwater Table Elevation for all Critical Water Years Alternative 2 With TUCP Without VA Compared to the No Action Alternative

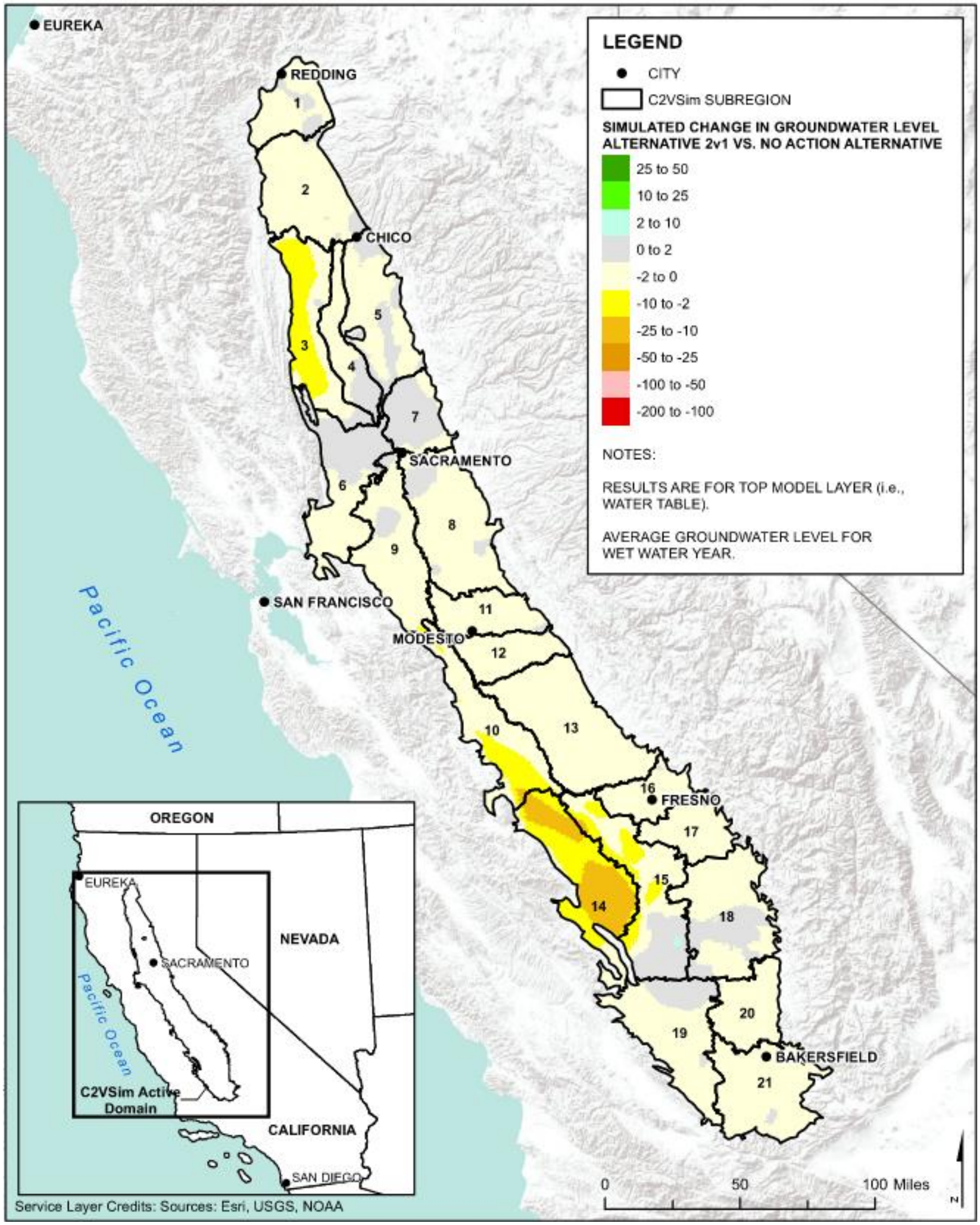


Figure I-105. Average Simulated Change in Groundwater Table Elevation for all Wet Water Years Alternative 2 Without TUCP Without VA Compared to the No Action Alternative

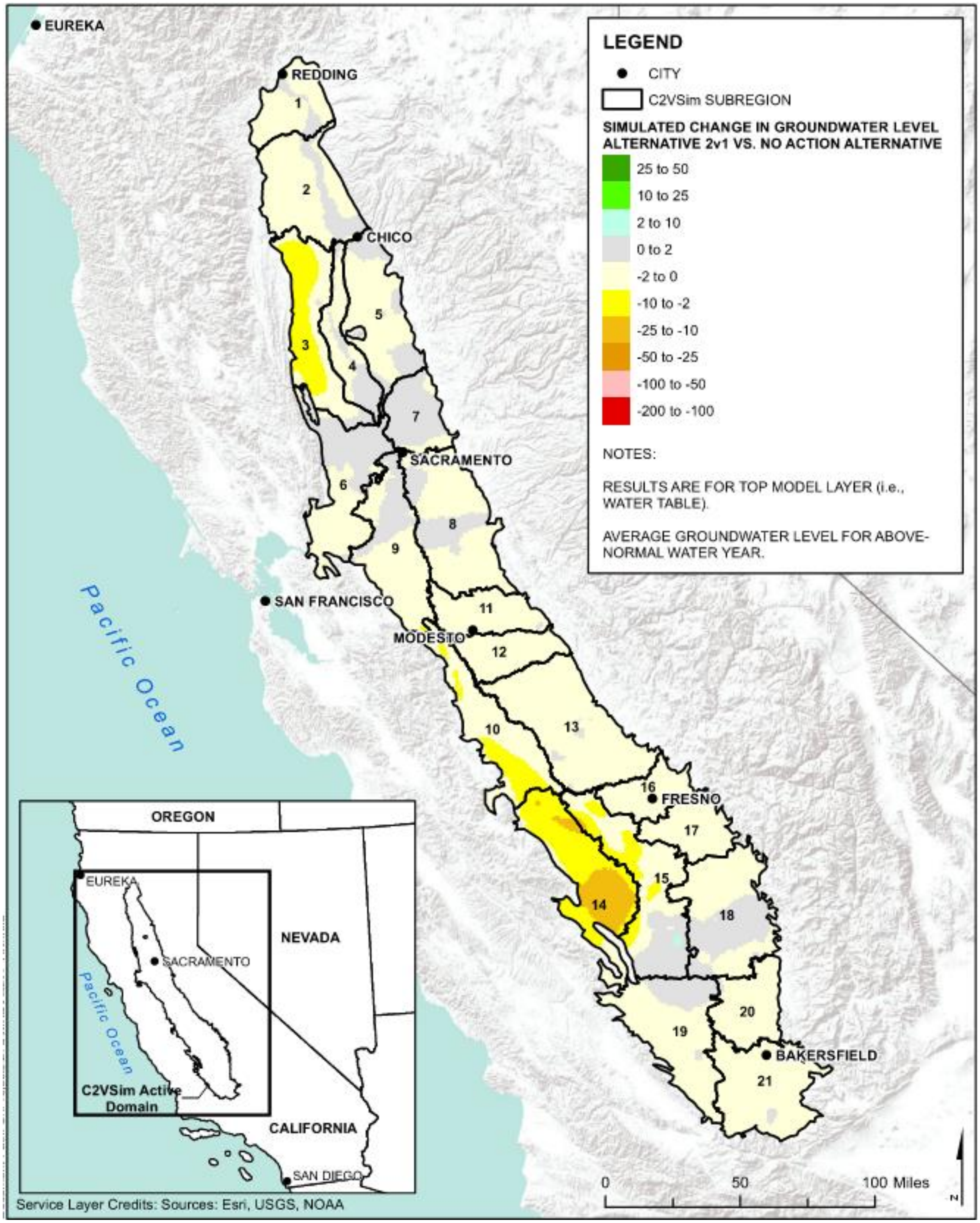
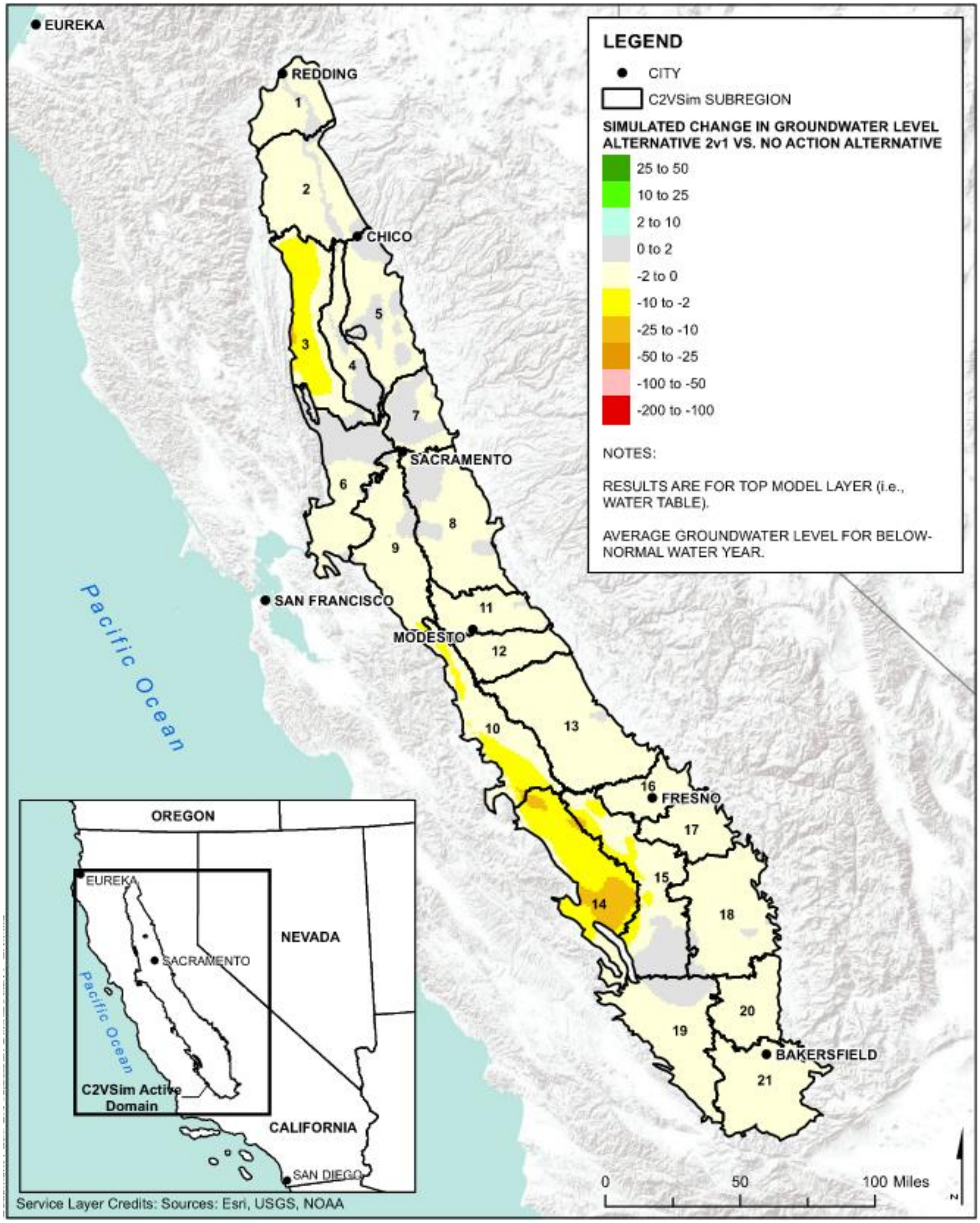


Figure I-106. Average Simulated Change in Groundwater Table Elevation for all Above Normal Water Years Alternative 2 Without TUCP Without VA Compared to the No Action Alternative



NOTES:

RESULTS ARE FOR TOP MODEL LAYER (i.e., WATER TABLE).

AVERAGE GROUNDWATER LEVEL FOR BELOW-NORMAL WATER YEAR.

Service Layer Credits: Sources: Esri, USGS, NOAA

Figure I-107. Average Simulated Change in Groundwater Table Elevation for all Below Normal Water Years Alternative 2 Without TUCP Without VA Compared to the No Action Alternative

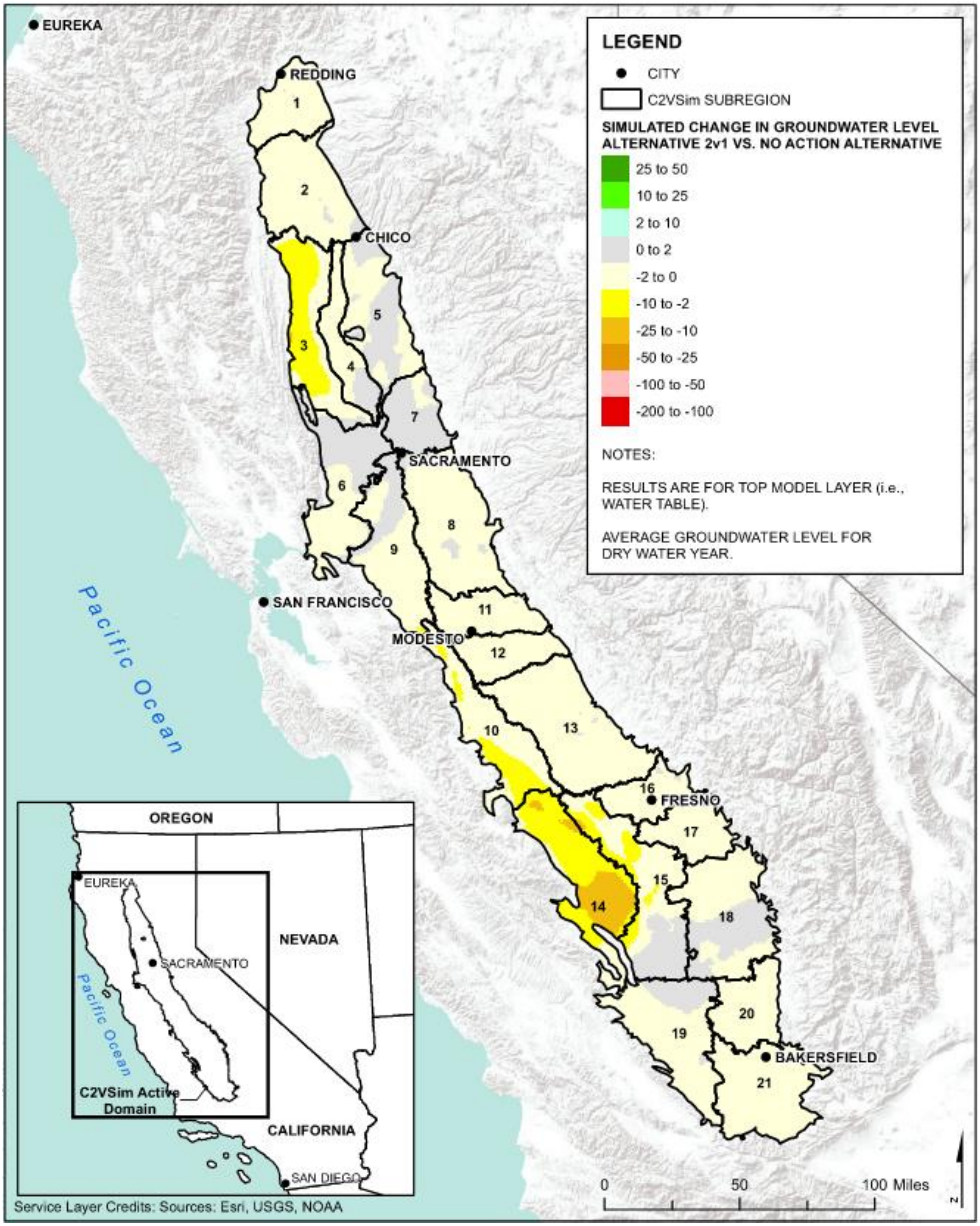


Figure I-108. Average Simulated Change in Groundwater Table Elevation for all Dry Water Years Alternative 2 Without TUCP Without VA Compared to the No Action Alternative

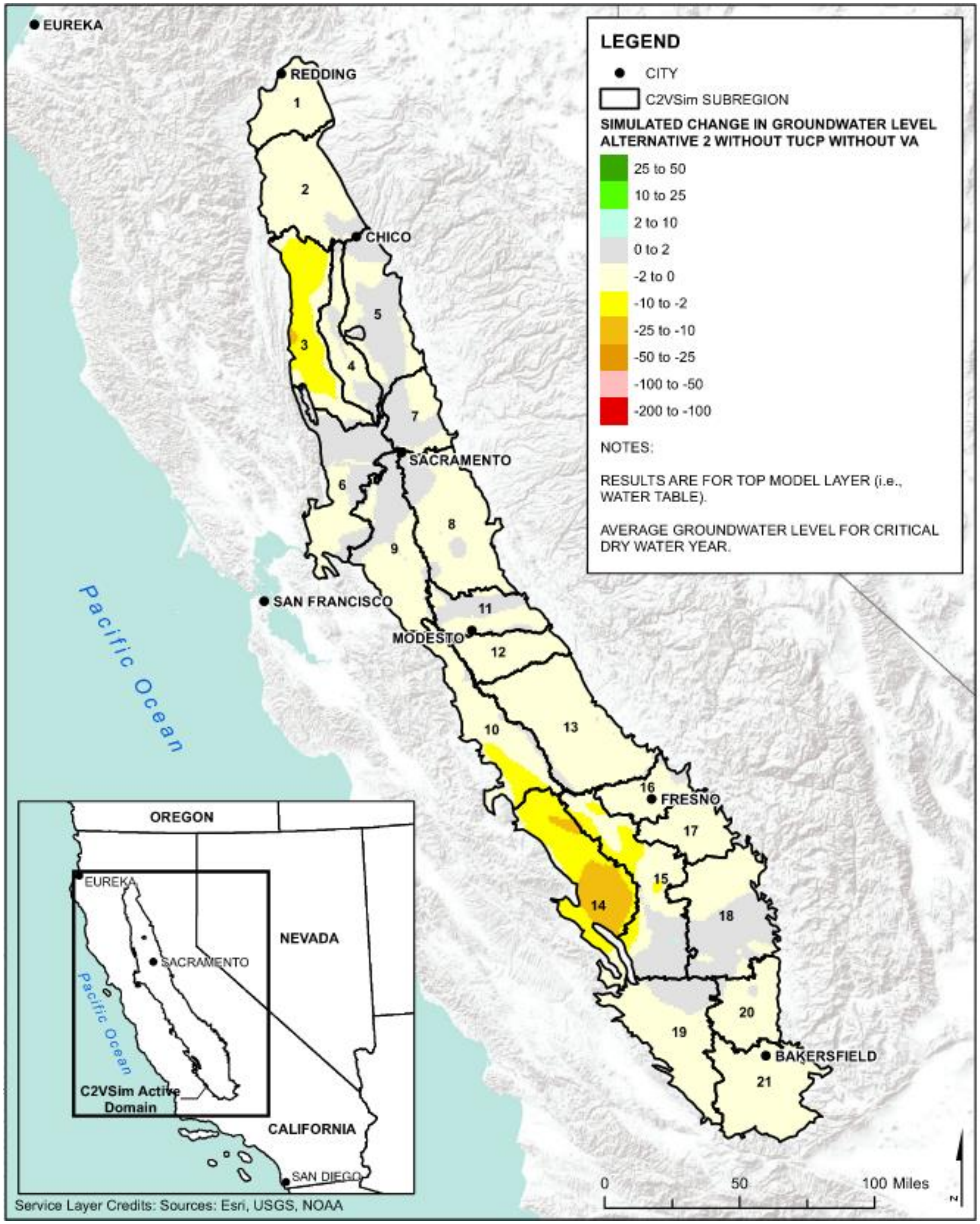


Figure I-109. Average Simulated Change in Groundwater Table Elevation for all Critical Water Years Alternative 2 Without TUCP Without VA Compared to the No Action Alternative

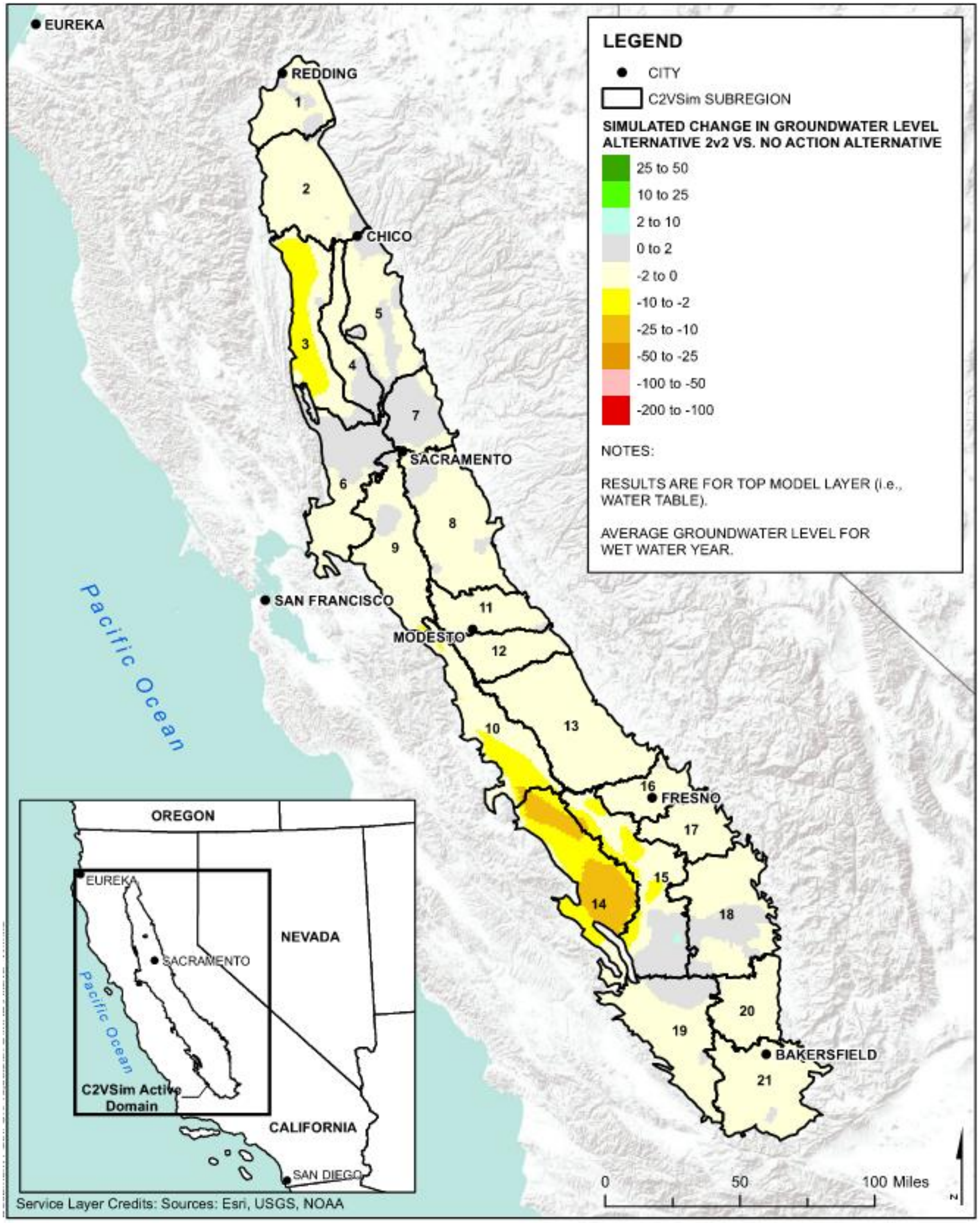


Figure I-110. Average Simulated Change in Groundwater Table Elevation for all Wet Water Years Alternative 2 Without TUCP Delta VA Compared to the No Action Alternative

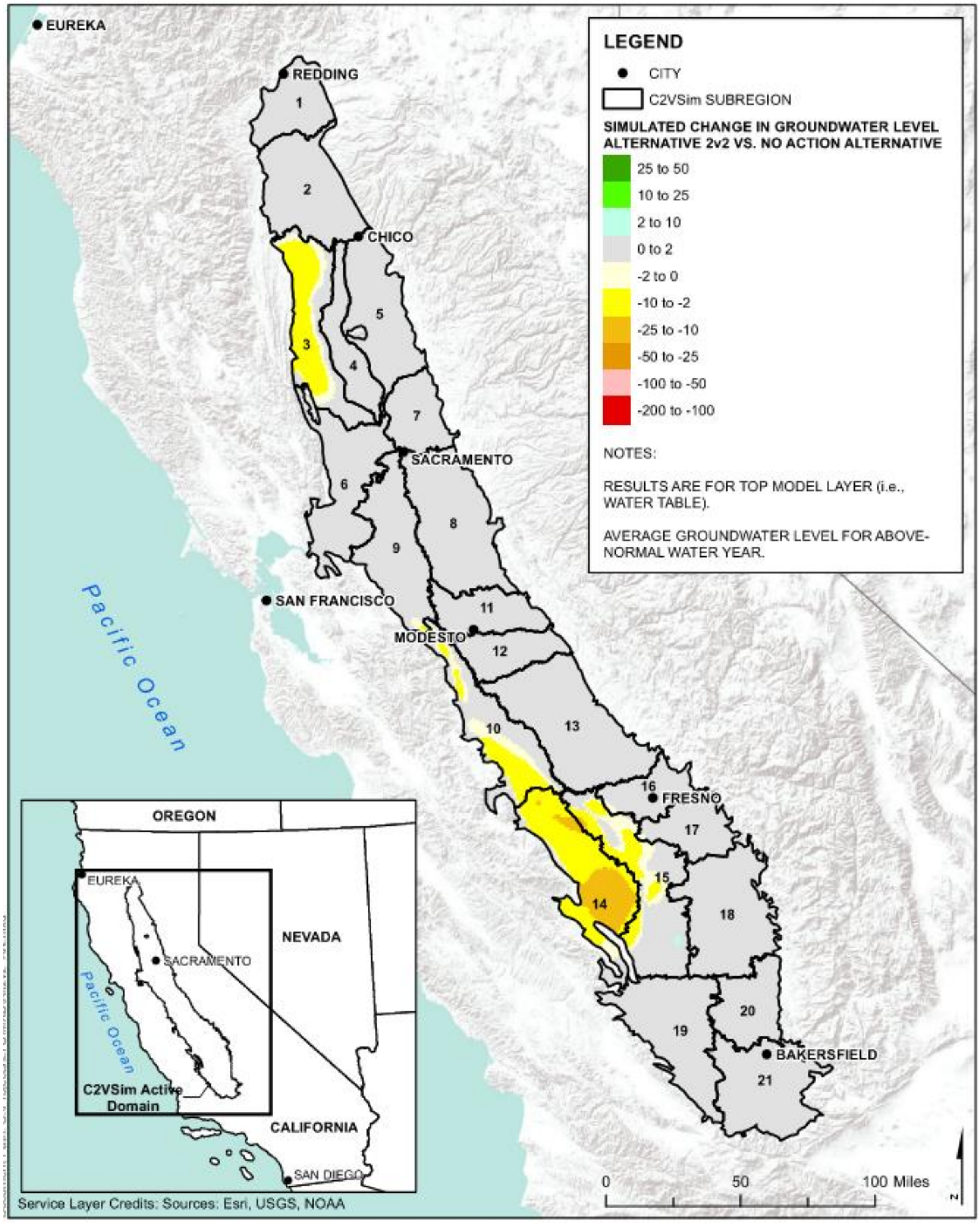


Figure I-111. Average Simulated Change in Groundwater Table Elevation for all Above Normal Water Years Alternative 2 Without TUCP Delta VA Compared to the No Action Alternative

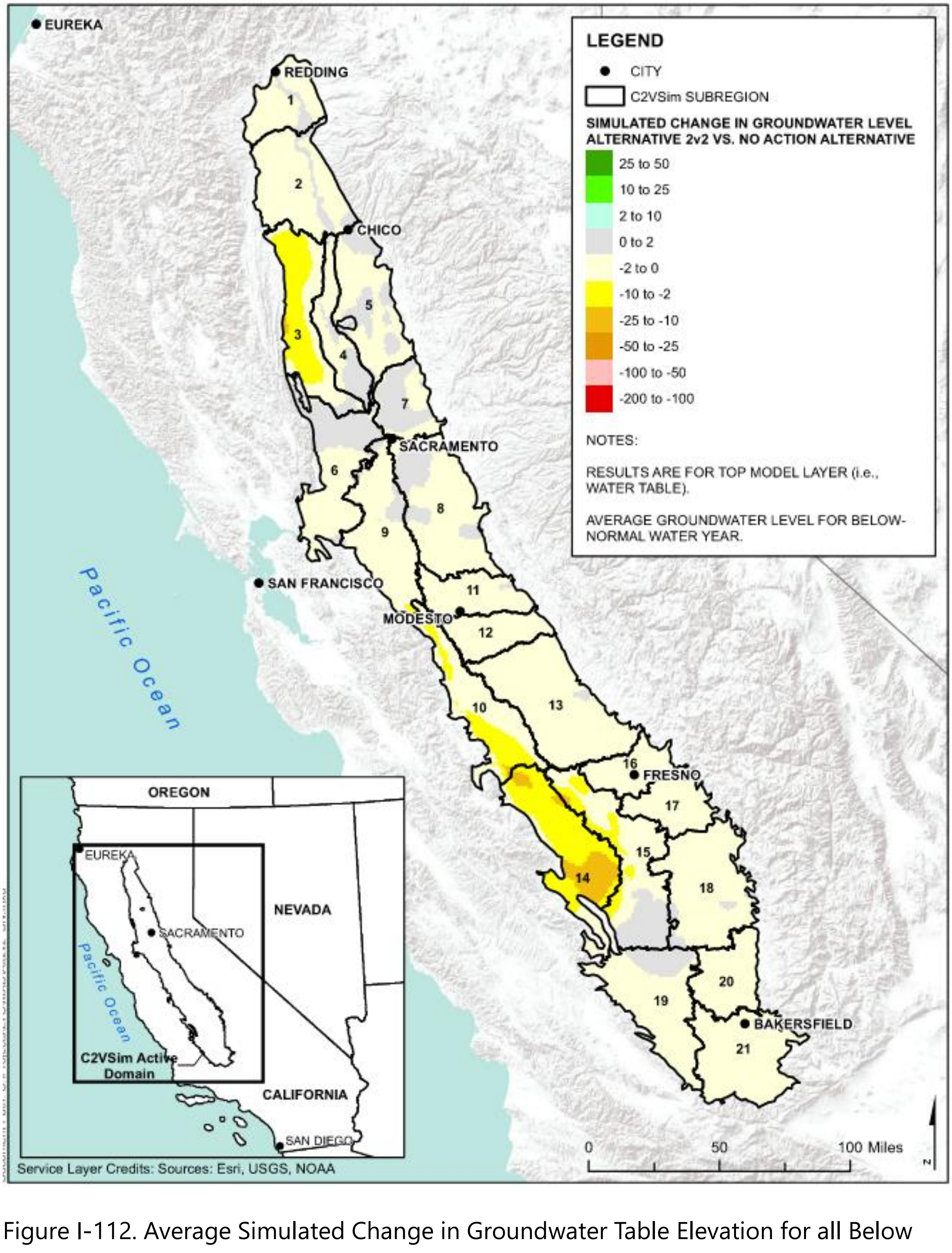
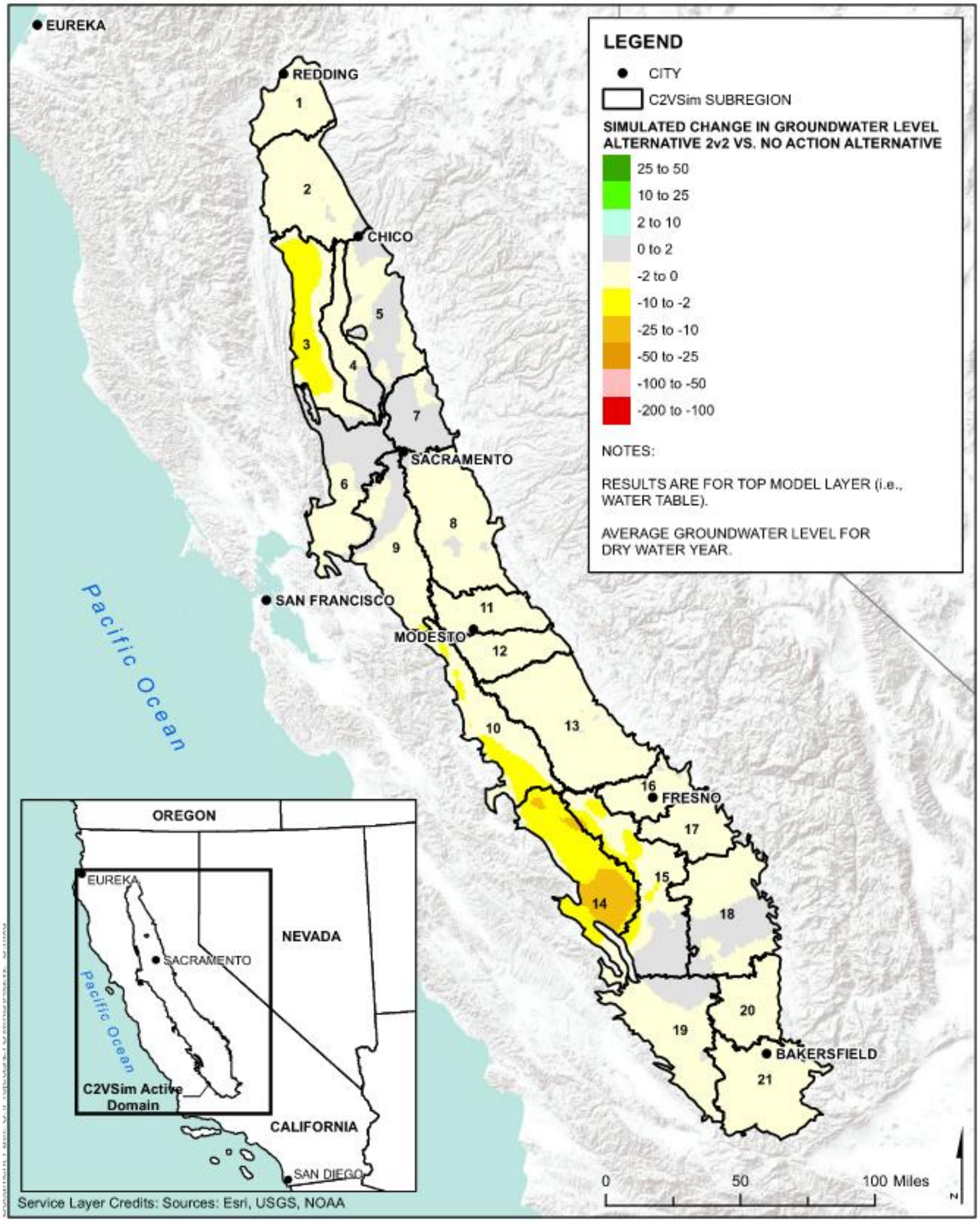


Figure I-112. Average Simulated Change in Groundwater Table Elevation for all Below Normal Water Years Alternative 2 Without TUCP Delta VA Compared to the No Action Alternative



NOTES:

RESULTS ARE FOR TOP MODEL LAYER (i.e., WATER TABLE).

AVERAGE GROUNDWATER LEVEL FOR DRY WATER YEAR.

Service Layer Credits: Sources: Esri, USGS, NOAA

Figure I-113. Average Simulated Change in Groundwater Table Elevation for all Dry Water Years Alternative 2 Without TUCP Delta VA Compared to the No Action Alternative

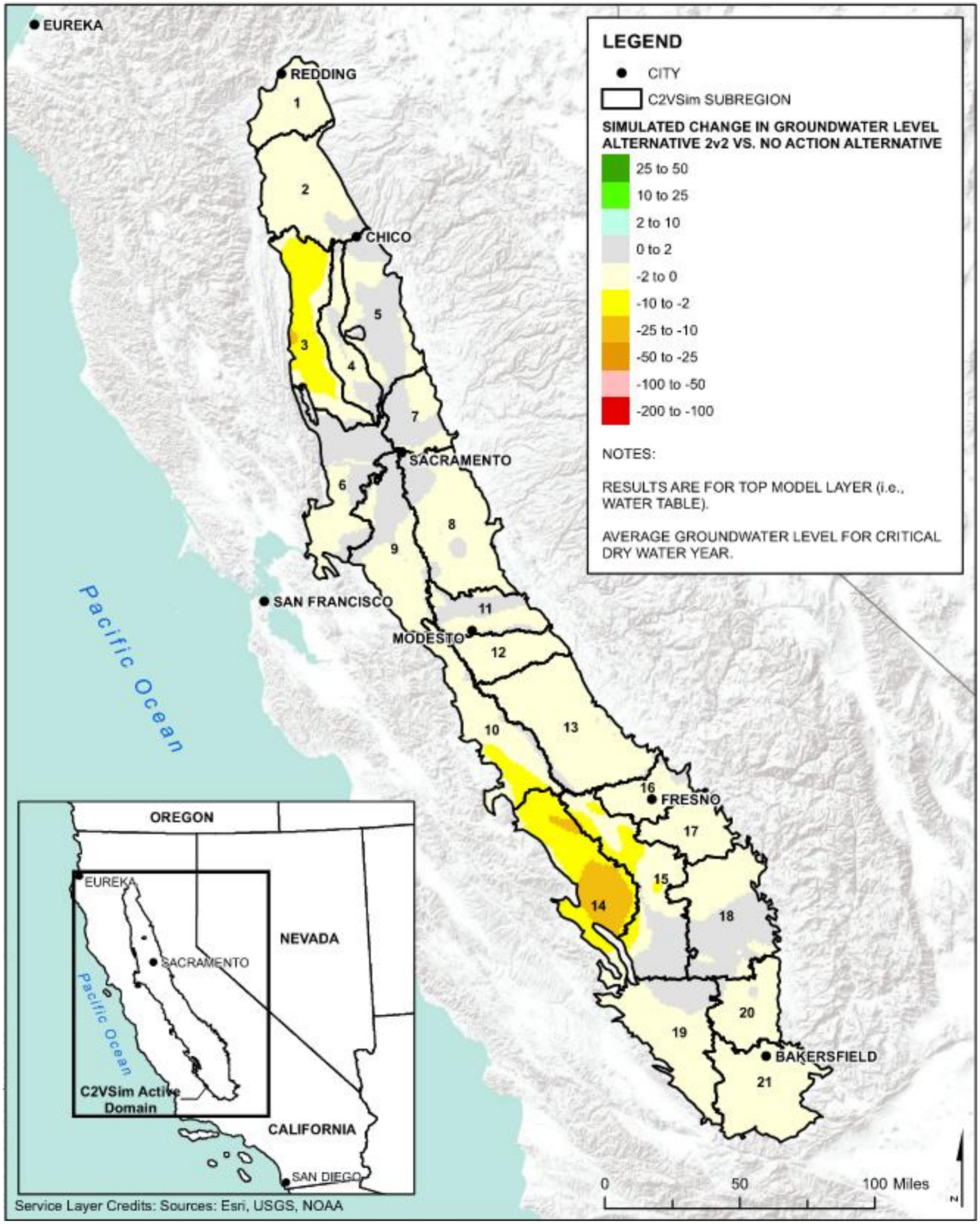


Figure I-114. Average Simulated Change in Groundwater Table Elevation for all Critical Water Years Alternative 2 Without TUCP Delta VA Compared to the No Action Alternative

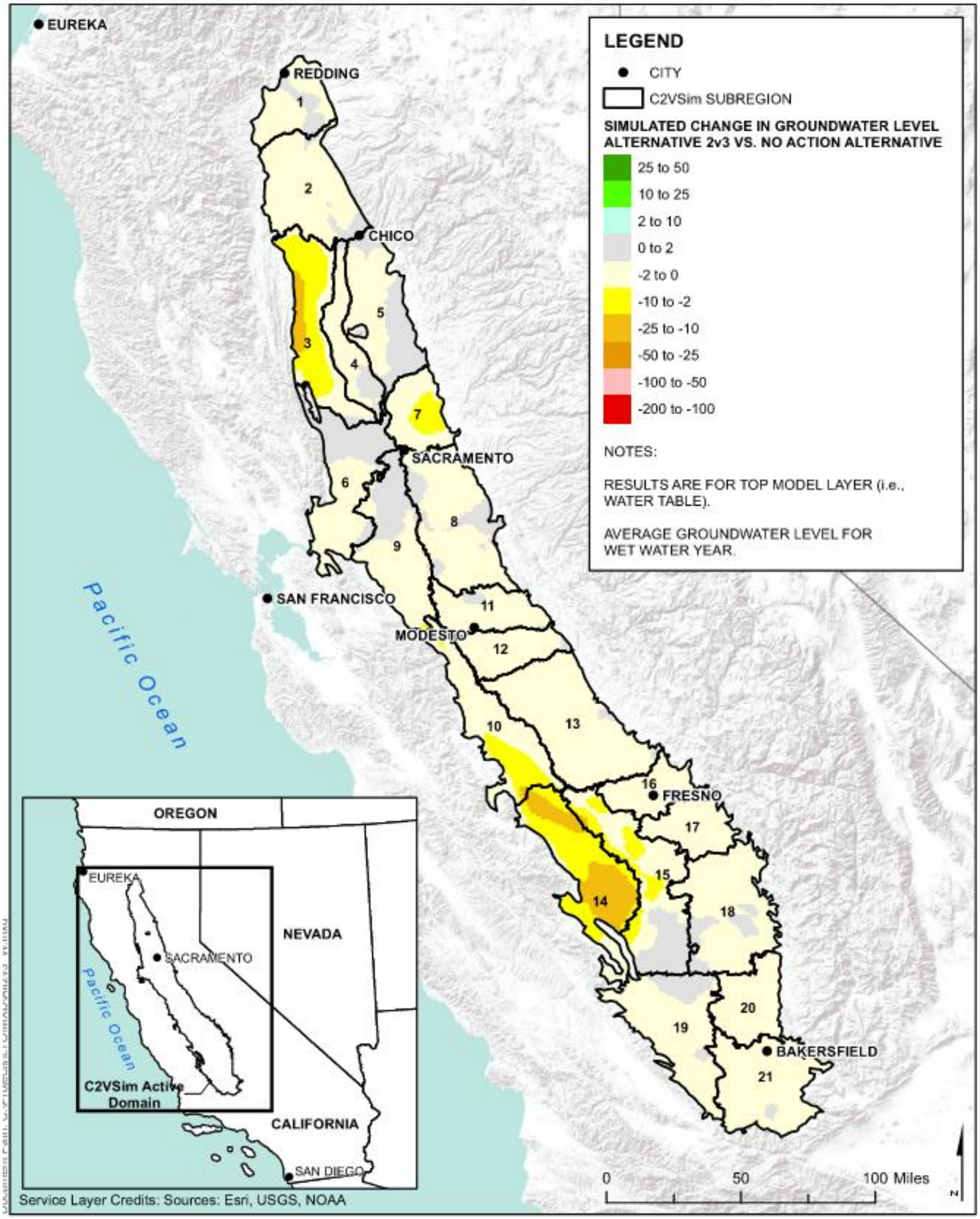


Figure I-115. Average Simulated Change in Groundwater Table Elevation for all Wet Water Years Alternative 2 Without TUCP Systemwide VA Compared to the No Action Alternative

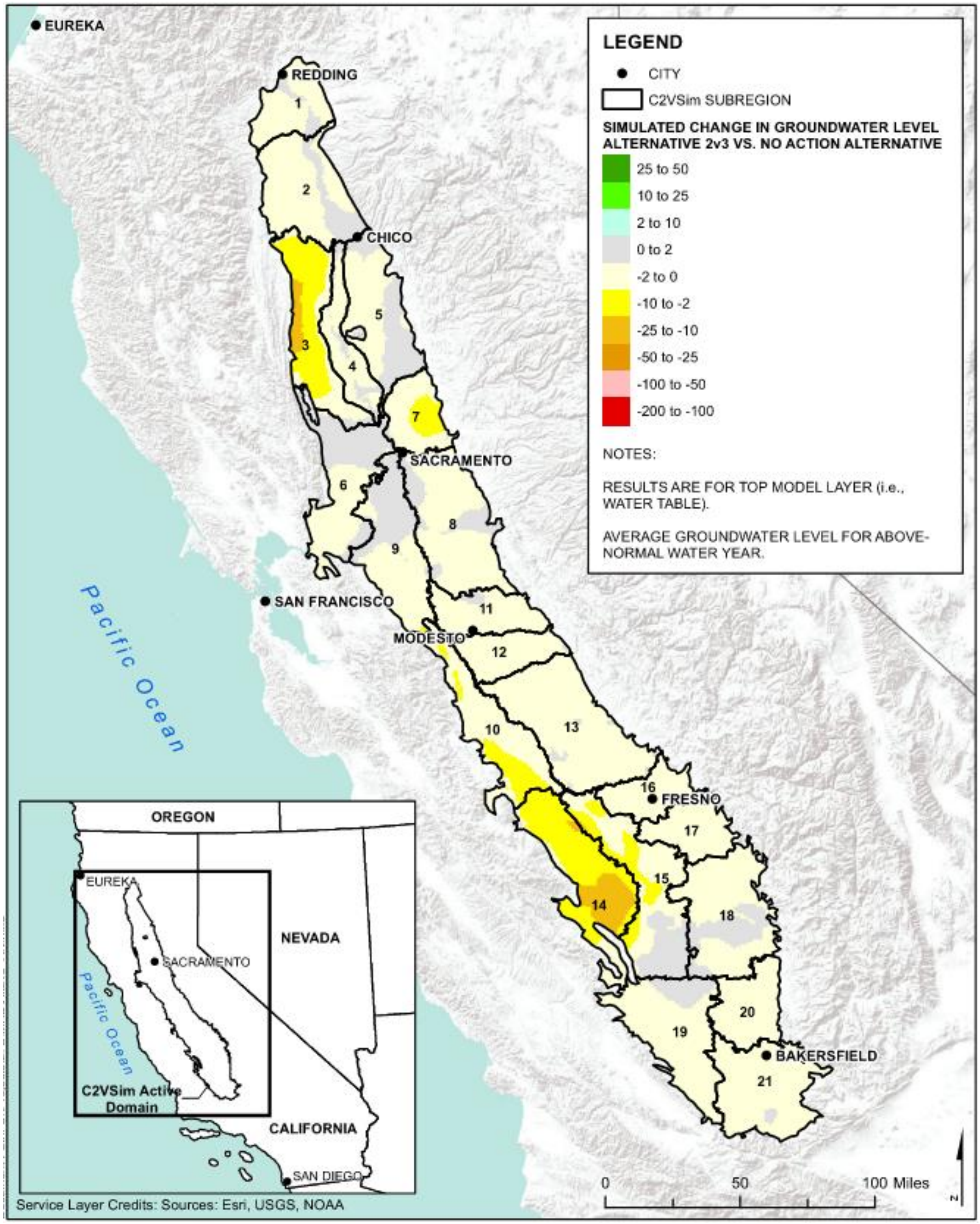
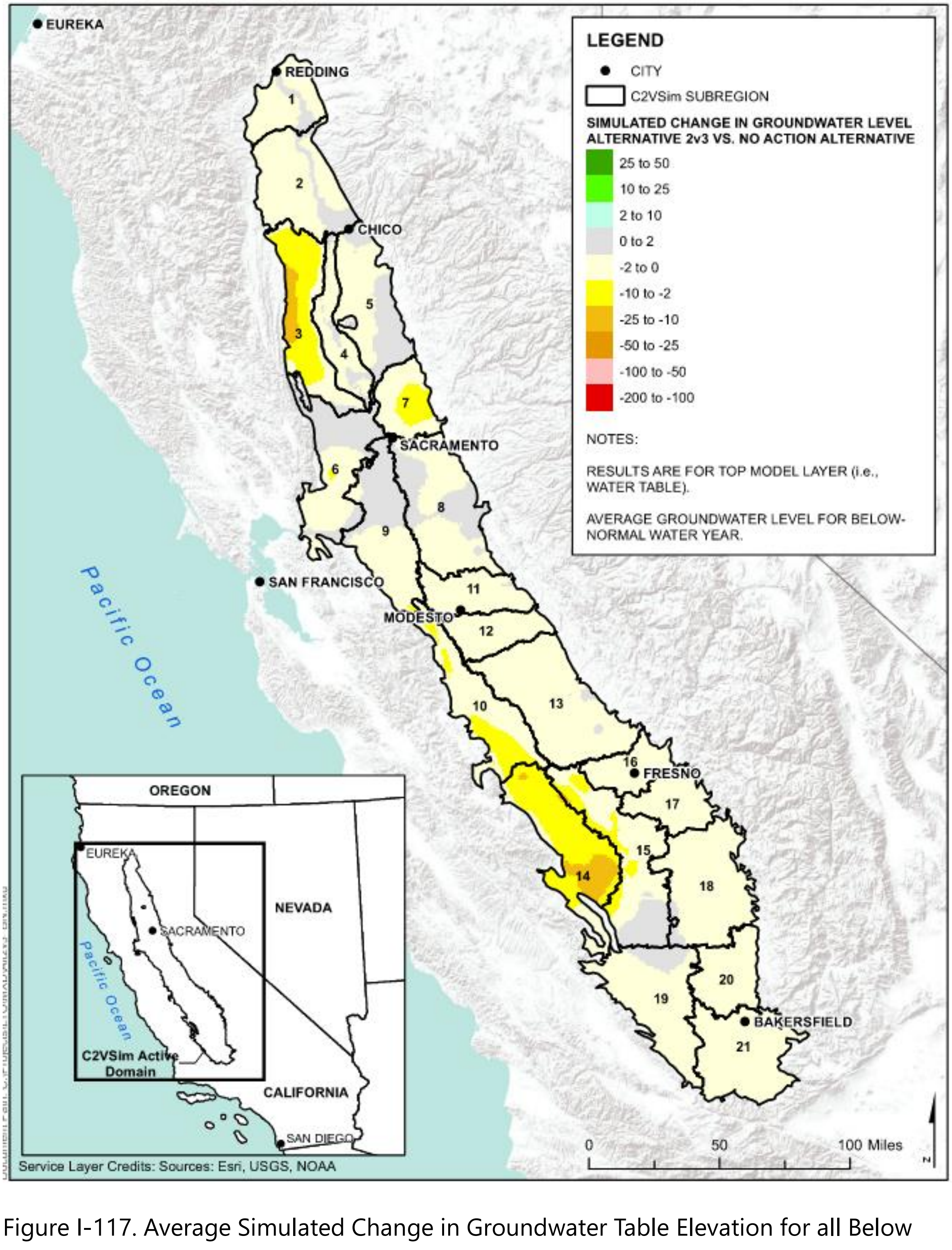


Figure I-116. Average Simulated Change in Groundwater Table Elevation for all Above Normal Water Years Alternative 2 Without TUCP Systemwide VA Compared to the No Action Alternative



NOTES:

RESULTS ARE FOR TOP MODEL LAYER (i.e., WATER TABLE).

AVERAGE GROUNDWATER LEVEL FOR BELOW-NORMAL WATER YEAR.

Service Layer Credits: Sources: Esri, USGS, NOAA

Figure I-117. Average Simulated Change in Groundwater Table Elevation for all Below Normal Water Years Alternative 2 Without TUCP Systemwide VA Compared to the No Action Alternative

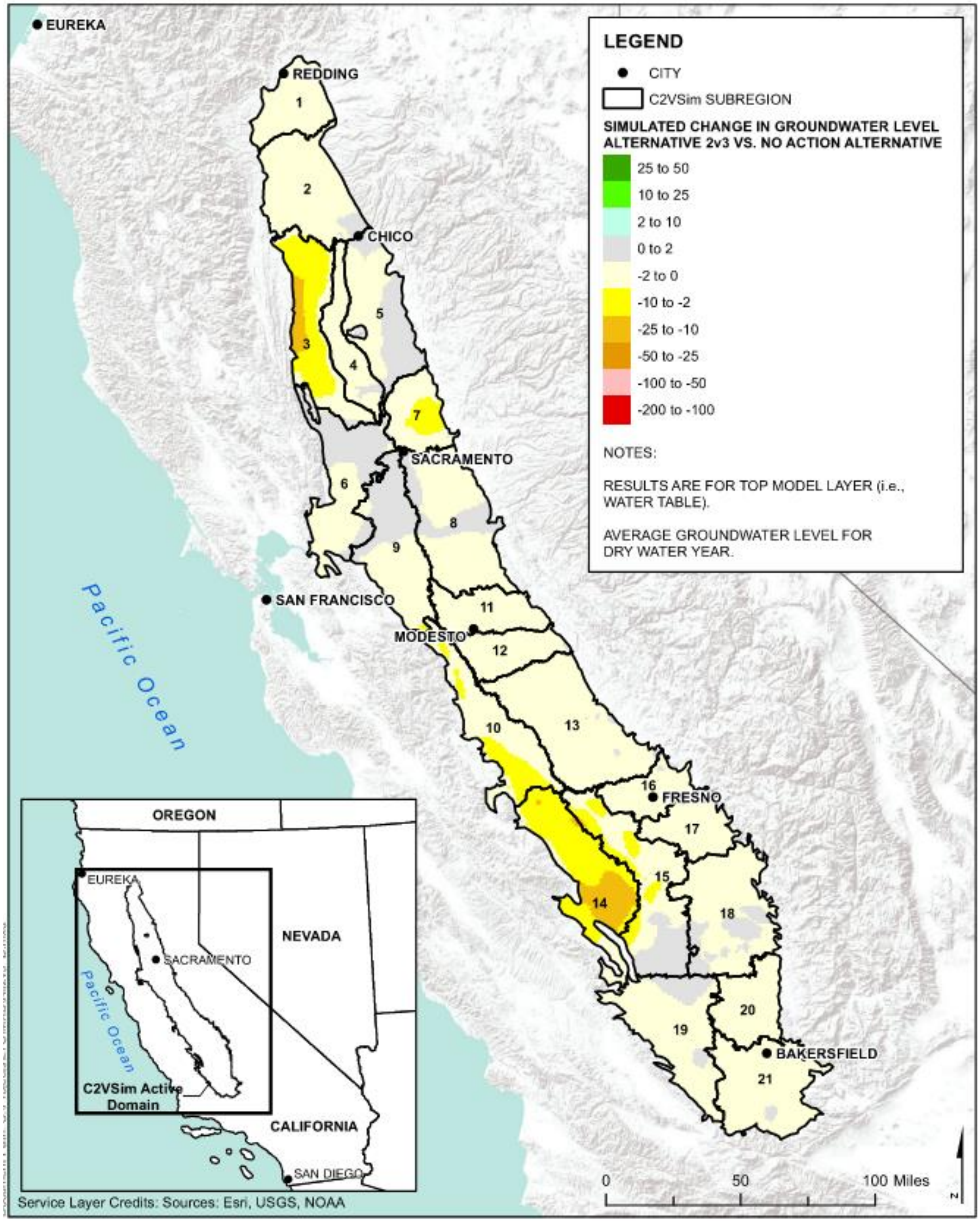


Figure I-118. Average Simulated Change in Groundwater Table Elevation for all Dry Water Years Alternative 2 Without TUCP Systemwide VA Compared to the No Action Alternative

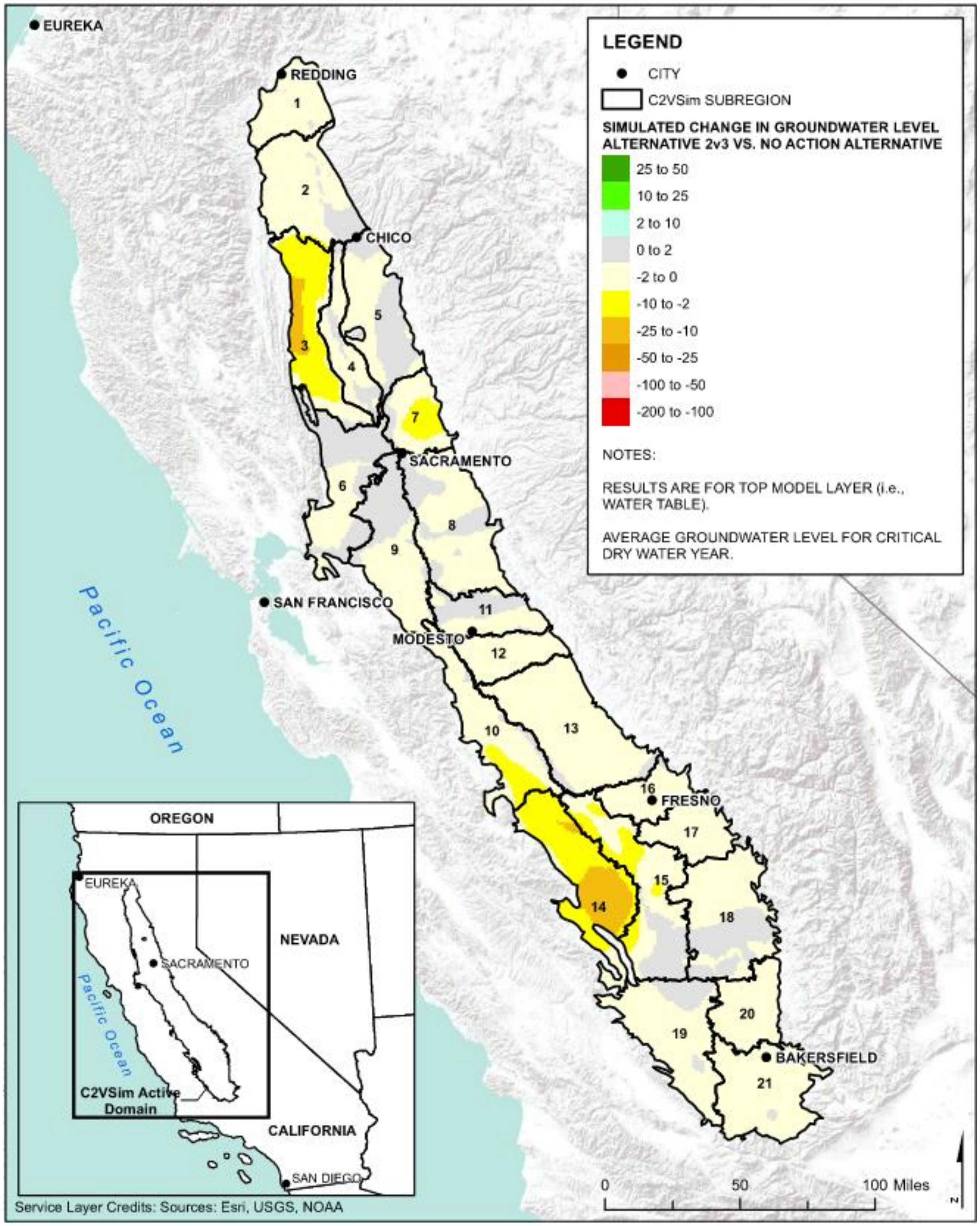


Figure I-119. Average Simulated Change in Groundwater Table Elevation for all Critical Water Years Alternative 2 Without TUCP Systemwide VA Compared to the No Action Alternative

Table I-15. Simulated Change in Groundwater Table Elevation (feet) in the Central Valley for Alternative 2 With TUCP Without VA Compared to the No Action Alternative for Each Water Year Type

Elevation	Wet	Above Normal	Below Normal	Dry	Critical
Average	-0.1	-0.1	-0.2	-0.2	-0.2
Maximum	2.9	3.0	2.2	2.3	1.8
Minimum	-9.6	-9.1	-9.4	-10.0	-12.7

Table I-16. Simulated Change in Groundwater Table Elevation (feet) in the Central Valley for Alternative 2 Without TUCP Without VA Compared to the No Action Alternative for Each Water Year Type

Elevation	Wet	Above Normal	Below Normal	Dry	Critical
Average	-0.2	-0.2	-0.2	-0.2	-0.2
Maximum	2.7	2.7	1.2	1.9	2.0
Minimum	-11.9	-10.9	-12.4	-12.1	-13.8

Table I-17. Simulated Change in Groundwater Table Elevation (feet) in the Central Valley for Alternative 2 Without TUCP Delta VA Compared to the No Action Alternative for Each Water Year Type

Elevation	Wet	Above Normal	Below Normal	Dry	Critical
Average	-0.6	-0.6	-0.6	-0.6	-0.6
Maximum	4.0	3.9	1.6	1.5	2.6
Minimum	-18.6	-16.8	-15.8	-16.8	-17.5

Table I-18. Simulated Change in Groundwater Table Elevation (feet) in the Central Valley for Alternative 2 Without TUCP Systemwide VA Compared to the No Action Alternative for Each Water Year Type

Elevation	Wet	Above Normal	Below Normal	Dry	Critical
Average	-0.7	-0.7	-0.7	-0.7	-0.8
Maximum	2.3	2.6	1.0	0.9	1.4
Minimum	-18.1	-16.1	-17.7	-17.4	-19.5

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Central Valley is not known, and therefore this impact cannot be quantified.

Central Coast Region

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The C2VSimFG model does simulate pumping in this region. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Any increase in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels. Surface water supply deliveries are discussed in Appendix H.

As discussed in the *Central Coast Region* subsection under Section I.2.3.1, groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Central Coast Region is not known, and therefore this impact cannot be quantified.

Southern California Region

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The C2VsimFG model does simulate pumping in this region. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Any increase in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels. Surface water supply deliveries are discussed in Appendix H.

As discussed in the *Southern California Region* subsection under Section I.2.4.1, groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Southern California Region is not known, and therefore this impact cannot be quantified.

I.2.4.4 Potential Changes in Land Subsidence

Trinity River

The area along the Trinity River is not known to be susceptible to subsidence and as was noted in the *Trinity River* subsection under Section I.2.4.1, groundwater pumping is not expected to increase in this region suggesting that subsidence will not be a concern in this area. Additional information related to subsidence is available in Appendix W.

Central Valley

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. In the Sacramento and San Joaquin Valleys, that reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Average groundwater levels are generally expected to remain the same or decrease the potential for additional subsidence exists. Average groundwater levels are simulated to decrease up to approximately 13 to 14 feet for Alternative 2 With TUCP Without VA and Alternative 2 Without TUCP Without VA in some water year types compared to the No Action Alternative. Groundwater levels may decrease closer to 19 to 20 feet for Alternative 2 Without TUCP Delta VA and Alternative 2 Without TUCP Systemwide VA compared to the No Action Alternative. The largest decreases in groundwater levels are simulated to occur along the western portion of the Central Valley in the Sacramento Valley (model subregion 3) and in the San Joaquin Valley (model subregion 14). Portions of these areas are known to have historic subsidence and further reductions in groundwater level may cause additional subsidence. Alternatives with larger decreases in groundwater levels have as higher likelihood of causes additional subsidence. The location and amount of subsidence is highly dependent on the local soil conditions and historical low groundwater levels in the area. Additional information related to soil conditions and subsidence is available in Appendix W

Central Coast Region

The Central Coast Region is not known to be susceptible to subsidence. However, increases in groundwater pumping may induce subsidence in areas where subsidence has not been recorded previous if groundwater levels and soil conditions allow. Additional information related to subsidence is available in Appendix W.

Southern California Region

The Southern California region is not known to be susceptible to subsidence. However, increases in groundwater pumping may induce subsidence in areas where subsidence has not been recorded previously if groundwater levels and soil conditions allow. Additional information related to subsidence is available in Appendix W.

I.2.4.5 Potential Changes in Groundwater Quality

Trinity River

Given that there is likely to be little change to groundwater conditions in this region either through pumping or groundwater-surface water interaction flow, there will similarly be little change to groundwater quality in the region.

Central Valley

Groundwater quality in the Central Valley has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

Central Coast Region

Similar to the Central Valley, groundwater quality in the Central Coast Region has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

Southern California Region

Similar to the Central Valley, groundwater quality has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

I.2.5 Alternative 3

I.2.5.1 Potential Changes in Groundwater Pumping

Trinity River

Operations in the Trinity River would remain similar to those under the No Action Alternative. The Trinity River Restoration Program Record of Decision controls Trinity River operations, and Reclamation would continue to release flows into the Trinity River as it does under the No Action Alternative.

Central Valley

Compared to the No Action Alternative, Alternative 3 would cause flow changes in the Sacramento River from changes to coldwater pool management and changes in Delta fall outflow requirements. Flow changes could affect surface water available for use by SWP and CVP contractors. Alternative 3 is expected to cause a change in the amount of surface water delivered to users in the Central Valley. This change in surface water supply will result in changes to groundwater pumping. Groundwater pumping is primarily expected to change as a result of changes in agricultural pumping. Table I-19 shows the simulated change in groundwater pumping in the Central Valley for Alternative 3 compared to the No Action Alternative. Alternative 3 results in an average annual increase in groundwater pumping of 626 TAF, with a maximum single year increase in groundwater pumping of 920 TAF and a maximum single year decrease in groundwater pumping of 74 TAF. Groundwater pumping results for each of the C2VSim subregions is provided in Attachment I-1. As noted in Section I.2.1, *Methods and Tools*, the C2VSimFG model does not simulate limitations to groundwater pumping that may be imposed as part of a local GSP. Therefore, the simulated groundwater pumping values simulated by C2VSimFG may overestimate the amount of groundwater pumping in certain areas.

Table I-19. Simulated Change in Groundwater Pumping in the Central Valley for Alternative 3 Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt3 minus NAA (TAF)	Alt3 minus NAA (% Difference)
1	W, W	608	5.3%
2	W, W	769	6.4%
3	C, C	400	2.5%
4	C, C	920	5.0%
5	AN, W	717	5.9%
6	BN, AN	530	4.4%
7	AN, W	564	5.1%
8	D, D	823	6.1%
9	W, W	707	6.9%
10	W, W	493	5.3%
11	W, AN	621	5.1%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt3 minus NAA (TAF)	Alt3 minus NAA (% Difference)
12	D, D	671	5.0%
13	W, W	691	6.2%
14	D, D	543	3.8%
15	C, C	665	4.3%
16	D, C	514	3.3%
17	C, C	212	1.3%
18	C, C	231	1.4%
19	C, C	74	0.4%
20	AN, W	702	5.9%
21	C, C	701	4.8%
22	W, W	832	7.8%
23	W, W	825	7.1%
24	W, W	696	6.0%
25	W, W	660	7.3%
26	W, AN	704	6.3%
27	AN, AN	782	6.3%
28	D, D	538	3.8%
29	D, D	785	5.3%
30	AN, BN	824	6.3%
31	BN, D	709	4.9%
32	AN, W	763	7.2%
33	W, W	660	6.4%
34	D, C	547	3.6%
35	C, C	753	4.9%
36	D, BN	392	2.5%
37	BN, AN	519	4.0%
38	W, W	648	6.4%
39	BN, D	665	4.8%
40	D, C	617	3.7%
41	C, C	729	3.8%
42	C, C	481	2.5%
Average		**626**	**4.9%**
Maximum		**920**	**7.8%**
Minimum		**74**	**0.4%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Central Coast Region

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered by each of the alternatives. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP.

The groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water originally sourced by surface deliveries. Surface deliveries from the SWP are also in some Central Coast basins, an important support for satisfying salinity standards. In these basins, existing salinity levels in the underlying groundwater would limit its use to replace reduced surface water deliveries needed to support both sources of recharge. Without the ongoing support of groundwater recharge in this region, groundwater levels may decrease, eventually resulting in reduced groundwater production.

Southern California Region

Similar to the Central Coast Region, the C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Southern California Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP.

The groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water originally sourced by surface deliveries. Surface deliveries from the SWP are also in some Southern California basins, an important support for satisfying salinity standards. In these basins, existing salinity levels in the underlying groundwater would limit its use to replace reduced surface water deliveries needed to support both sources of recharge. Without the ongoing support of groundwater recharge in this region, groundwater levels may decrease, eventually resulting in reduced groundwater production.

I.2.5.2 Potential Changes in Groundwater-Surface Water Interaction Flow

Trinity River

Most usable groundwater in the Trinity River Region occurs in widely scattered alluvium-filled valleys, such as those immediately adjacent to the Trinity River. These valleys contain only small quantities of recoverable groundwater and therefore are not considered a major source. Given this hydrogeologic nature of this region, changes in surface water flow will likely result in little change to the groundwater-surface water interaction flow.

Central Valley

Table I-20 shows the simulated change in groundwater-surface water interaction flow in the Central Valley for Alternative 3 compared to the No Action Alternative. Alternative 3 results in an average annual change in groundwater-surface water interaction flow of 455 TAF (increase in flow to surface water from groundwater), with a maximum single year increase in flow from groundwater to surface water of 809 TAF and a minimum single year increase in flow from surface water to groundwater of 245 TAF. Additional groundwater-surface water interaction flow results for each of the C2VSim subregions is provided in Attachment I-1.

Table I-20. Simulated Change in Groundwater-Surface Water Interaction Flow in the Central Valley for Alternative 3 Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt3 minus NAA (TAF)	Alt3 minus NAA (% Difference)
1	W, W	268	176.1%
2	W, W	268	368.4%
3	C, C	373	1301.7%
4	C, C	631	76.7%
5	AN, W	536	17.7%
6	BN, AN	469	64.2%
7	AN, W	303	28.4%
8	D, D	435	275.8%
9	W, W	383	71.1%
10	W, W	548	93.3%
11	W, AN	328	19.1%
12	D, D	406	38.4%
13	W, W	421	84.8%
14	D, D	486	72.4%
15	C, C	522	435.1%
16	D, C	558	83.5%
17	C, C	487	91.4%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt3 minus NAA (TAF)	Alt3 minus NAA (% Difference)
18	C, C	474	35.3%
19	C, C	519	33.2%
20	AN, W	245	12.7%
21	C, C	396	39.7%
22	W, W	408	19.0%
23	W, W	411	48.9%
24	W, W	490	85.7%
25	W, W	541	505.8%
26	W, AN	337	26.9%
27	AN, AN	376	60.1%
28	D, D	505	90.5%
29	D, D	433	688.2%
30	AN, BN	391	139.3%
31	BN, D	389	414.0%
32	AN, W	477	161.0%
33	W, W	560	397.8%
34	D, C	408	130.4%
35	C, C	572	228.7%
36	D, BN	503	76.8%
37	BN, AN	322	28.3%
38	W, W	595	68.3%
39	BN, D	424	442.5%
40	D, C	451	117.7%
41	C, C	657	70.1%
42	C, C	809	55.2%
Average		**455**	**173.2%**
Maximum		**809**	**1301.7%**
Minimum		**245**	**12.7%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Central Coast Region

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered by each of the alternatives. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

Southern California Region

Similar to the Central Coast Region, the C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

I.2.5.3 Potential Changes in Groundwater Elevation

Trinity River

Given that there is likely to be little change to the volume of groundwater either through pumping or groundwater-surface water interaction flow, there will be little change to groundwater levels in the area.

Central Valley

The C2VSimFG groundwater model provides simulated groundwater level over the entire model simulation period for every "node" in the model (nodes cover all subregions noted in Figure I-2). Figure I-3 through Figure I-94 show the simulated change in groundwater table elevation for each node with the implementation of Alternative 3 in comparison to the No Action Alternative. The figures also show the simulation results for the other alternatives discussed in other sections.

The predicted change in groundwater table elevation for Alternative 3 as compared to the No Action Alternative spans a range from a decrease of 198.5 feet to an increase of 6.2 feet. However, note that this range of potential change captures the predicted groundwater table elevations across all 92 locations shown in the figures.

Figure I-120 through Figure I-124 show the average simulated change in groundwater table elevation for each of the five water year types defined by DWR. Table I-21 shows the range of the change in groundwater levels for Alternative 3 as compared to the No Action Alternative.

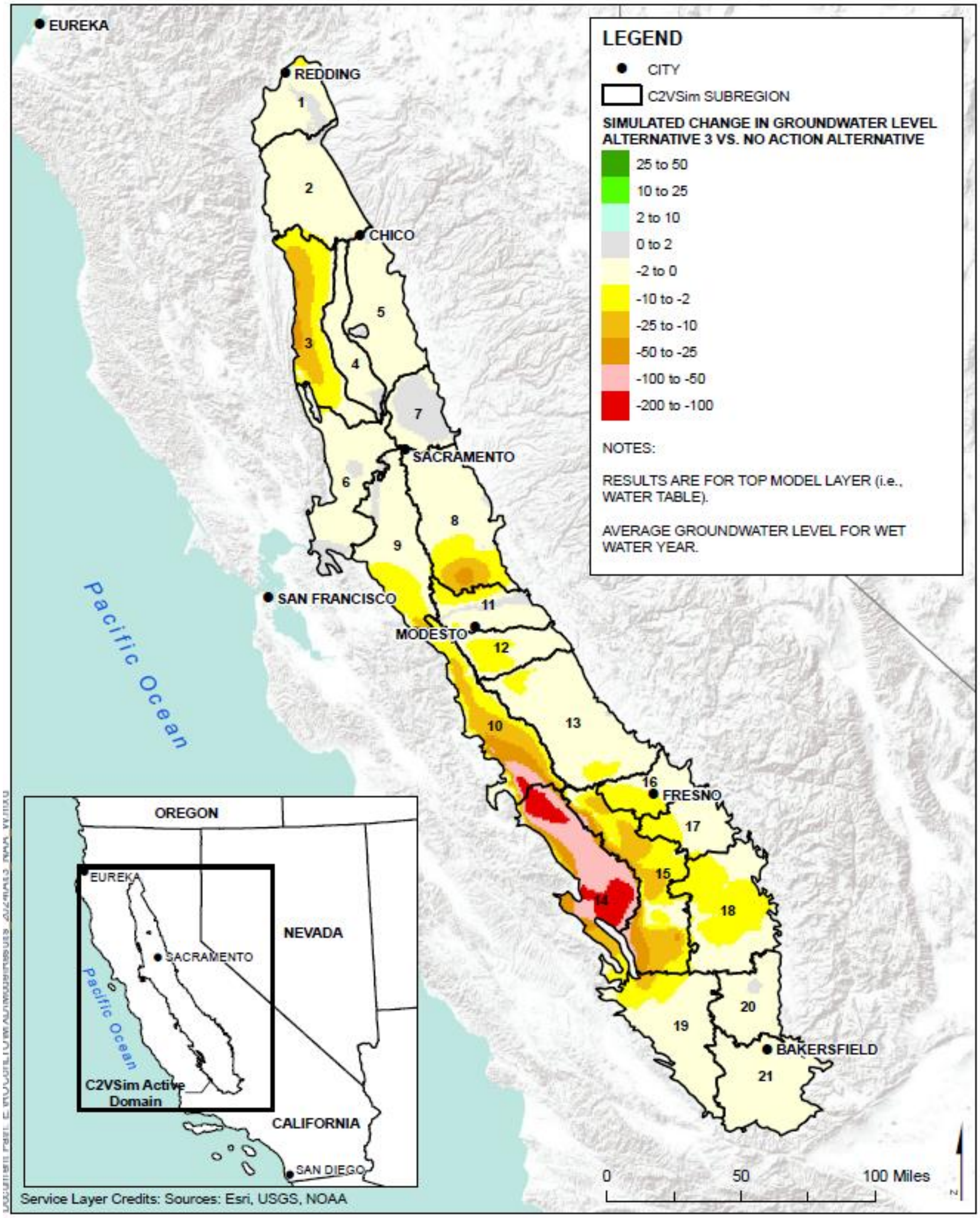


Figure I-120. Average Simulated Change in Groundwater Table Elevation for all Wet Water Years Alternative 3 Compared to the No Action Alternative

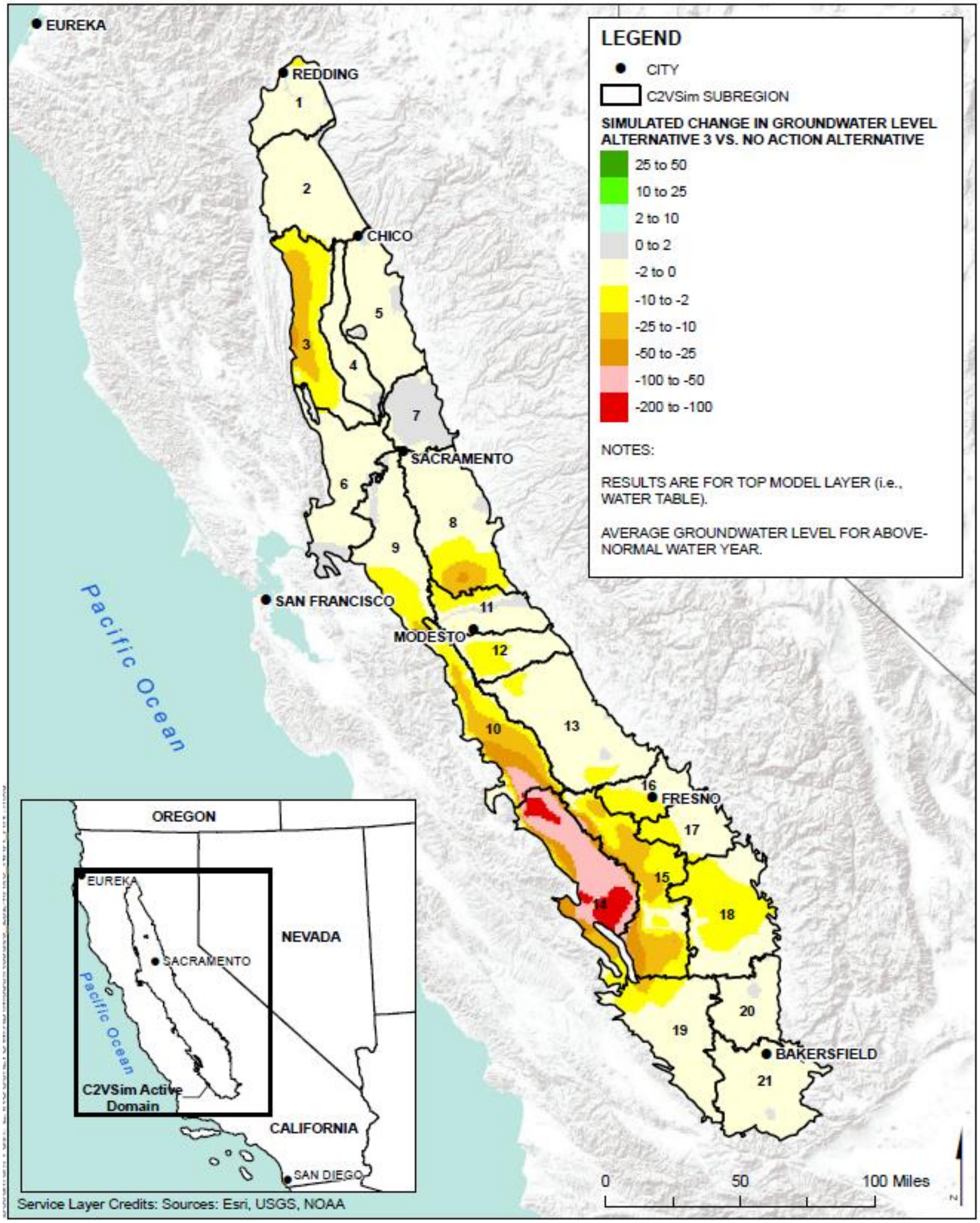


Figure I-121. Average Simulated Change in Groundwater Table Elevation for all Above Normal Water Years Alternative 3 Compared to the No Action Alternative

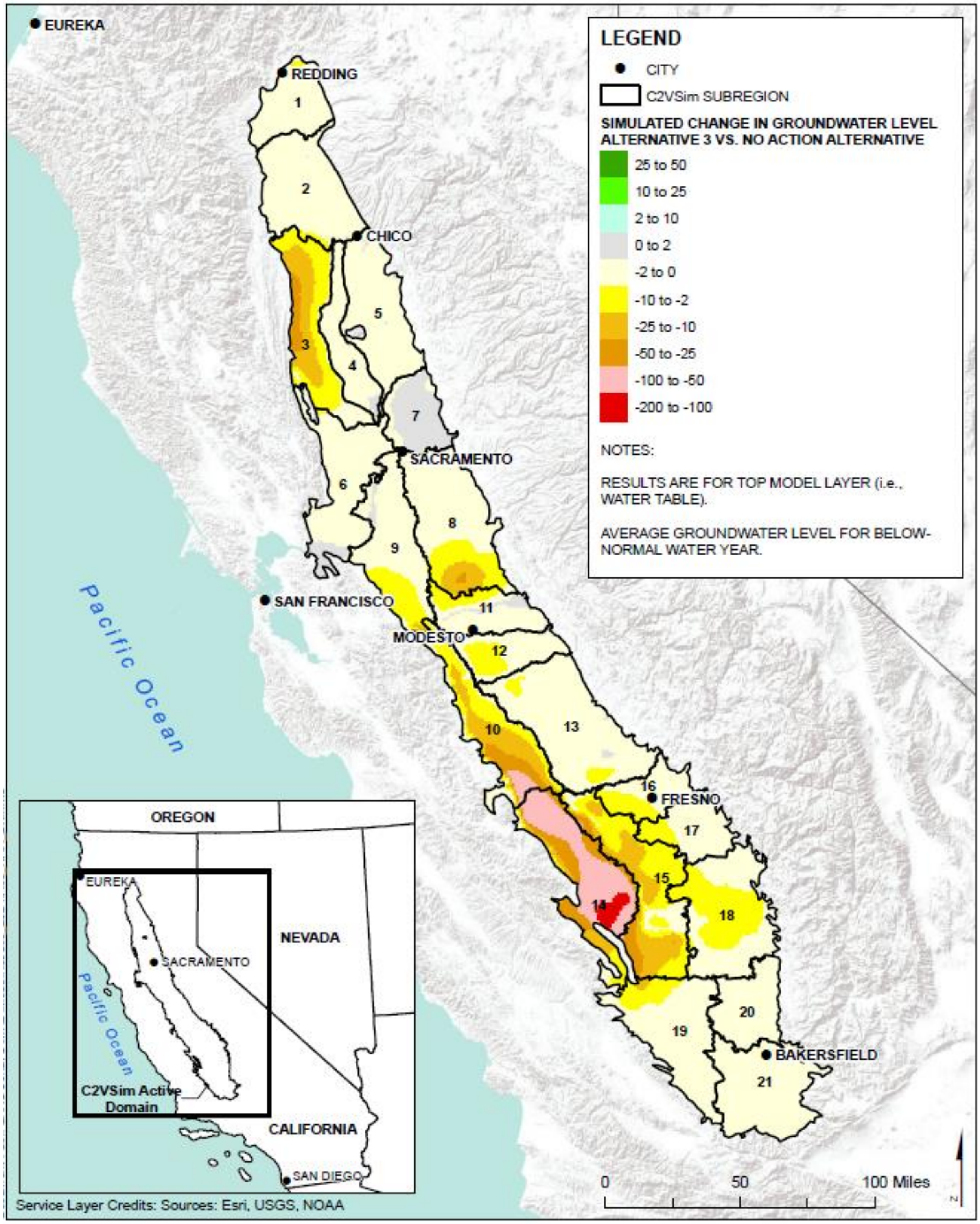
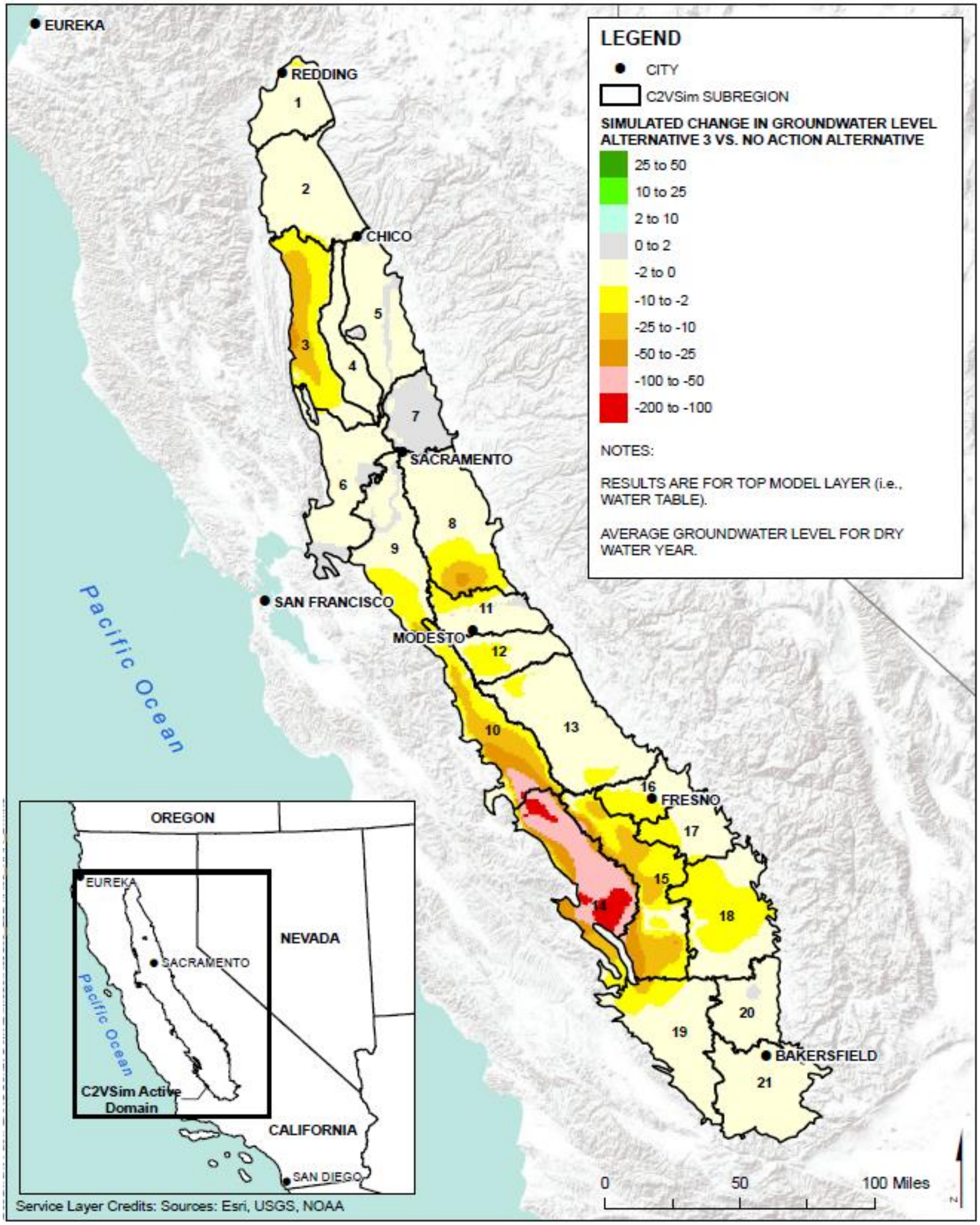


Figure I-122. Average Simulated Change in Groundwater Table Elevation for all Below Normal Water Years Alternative 3 Compared to the No Action Alternative



Service Layer Credits: Sources: Esri, USGS, NOAA

Figure I-123. Average Simulated Change in Groundwater Table Elevation for all Dry Water Years Alternative 3 Compared to the No Action Alternative

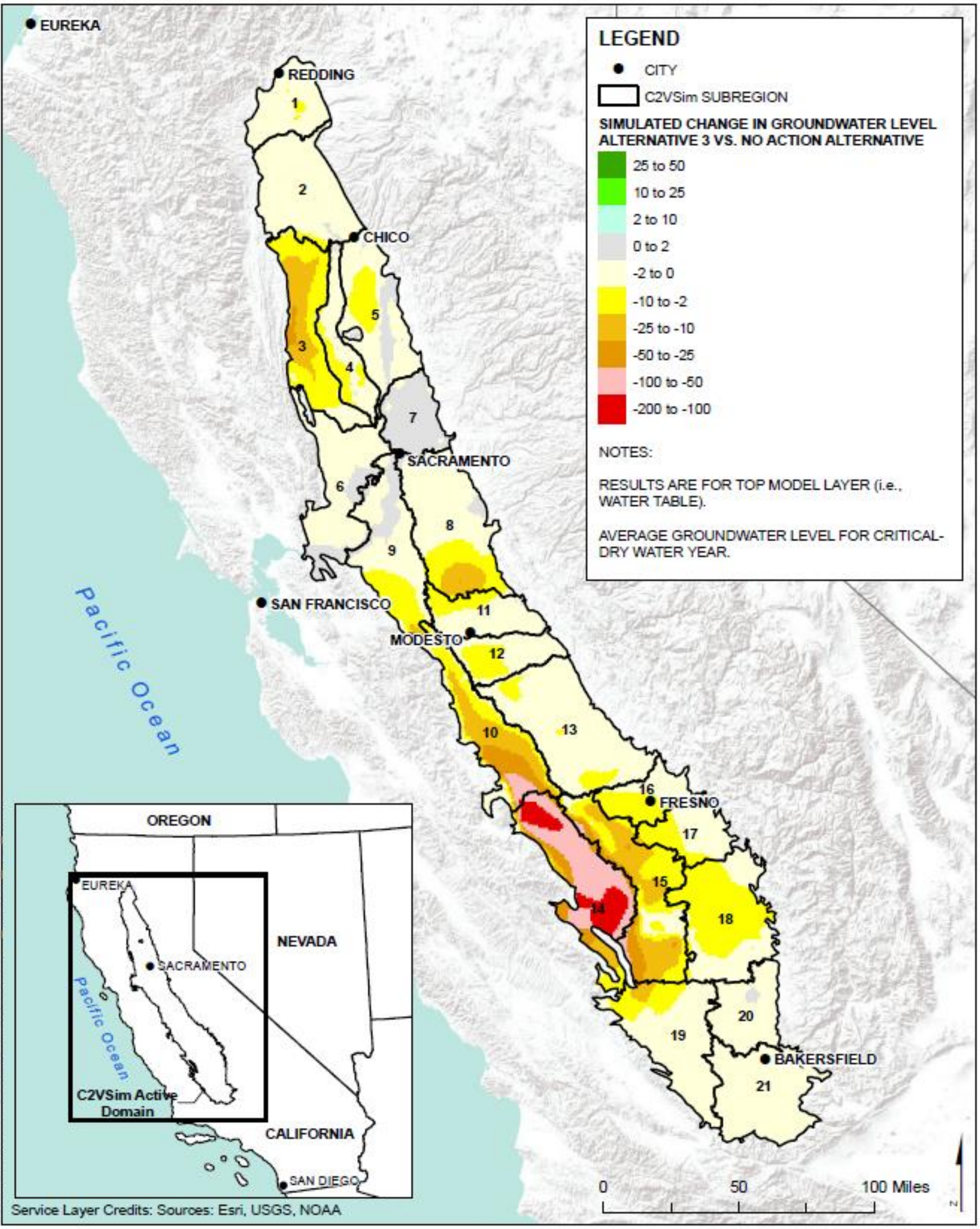


Figure I-124. Average Simulated Change in Groundwater Table Elevation for all Critical Water Years Alternative 3 Compared to the No Action Alternative

Table I-21. Simulated Change in Groundwater Table Elevation (feet) in the Central Valley for Alternative 3 Compared to the No Action Alternative for Each Water Year Type

Elevation	Wet	Above Normal	Below Normal	Dry	Critical
Average	-5.5	-5.1	-4.5	-5.0	-5.6
Maximum	0.5	0.7	0.5	0.7	2.4
Minimum	-158.6	-145.9	-125.0	-143.7	-155.2

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Central Valley is not known, and therefore this impact cannot be quantified.

Central Coast Region

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The C2VSimFG model does simulate pumping in this region. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Any increase in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels. Surface water supply deliveries are discussed in Appendix H.

As discussed in the *Central Coast Region* subsection under Section I.2.5.1 groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Central Coast Region is not known, and therefore this impact cannot be quantified.

Southern California Region

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The C2VSimFG model does simulate pumping in this region. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Any increase in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels. Surface water supply deliveries are discussed in Appendix H.

As discussed in the *Southern California Region* subsection under Section I.2.5.1, groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Southern California Region is not known, and therefore this impact cannot be quantified.

I.2.5.4 Potential Changes in Land Subsidence

Trinity River

The area along the Trinity River is not known to be susceptible to subsidence and, as noted above in the *Trinity River* subsection under Section I.2.5.1, groundwater pumping is not expected to increase in this region, suggesting that subsidence will not be a concern in this area. Additional information related to subsidence is available in Appendix W.

Central Valley

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. In the Sacramento and San Joaquin valleys, that reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Groundwater levels are generally expected to remain the same or decrease the potential for additional subsidence exists. Average groundwater levels are simulated to decrease up to approximately 160 feet for Alternative 3 in some water year types compared to the No Action Alternative. The largest decreases in groundwater levels are simulated to occur along the western portion of the Central Valley in the Sacramento Valley (model subregion 3) and in the San Joaquin Valley (model subregions 10 and 14). Additional areas of decreased groundwater levels appear north of Modesto (model subregion 8) and south of Fresno (model subregions 15 through 18). Given the relatively large decreases in groundwater elevations and the fact that portions of these areas are known to have historic subsidence, the potential for additional subsidence is high. The location and amount of subsidence is highly dependent on the local soil conditions and historical low groundwater levels in the area. Additional information related to soil conditions and subsidence is available in Appendix W.

Central Coast Region

The Central Coast Region is not known to be susceptible to subsidence. However, increases in groundwater pumping may induce subsidence in areas where subsidence has not been recorded previous if groundwater levels and soil conditions allow. Additional information related to subsidence is available in Appendix W.

Southern California Region

The Southern California region is not known to be susceptible to subsidence. However, increases in groundwater pumping may induce subsidence in areas where subsidence has not been recorded previously if groundwater levels and soil conditions allow. Additional information related to subsidence is available in Appendix W.

I.2.5.5 Potential Changes in Groundwater Quality

Trinity River

Given that there is likely to be little change to groundwater conditions in this region either through pumping or groundwater-surface water interaction flow, there will similarly be little change to groundwater quality in the region.

Central Valley

Groundwater quality in the Central Valley has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

Central Coast Region

Similar to the Central Valley, groundwater quality in the Central Coast Region has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

Southern California Region

Similar to the Central Valley, groundwater quality has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and water quality constituents present.

I.2.6 Alternative 4

I.2.6.1 Potential Changes in Groundwater Pumping

Trinity River

Operations in the Trinity River would remain similar to those under the No Action Alternative. The Trinity River Restoration Program Record of Decision controls Trinity River operations, and Reclamation would continue to release flows into the Trinity River as it does under the No Action Alternative.

Central Valley

Table I-22 shows the simulated change in groundwater pumping in the Central Valley for of Alternative 4 compared to the No Action Alternative. Alternative 4 results in an average annual decrease in groundwater pumping of 15 TAF, with a maximum single year increase in groundwater pumping of 181 TAF and a maximum single year decrease in groundwater pumping of 215 TAF. Groundwater pumping results for each of the C2VSim subregions is provided in Attachment I-1. As noted in Section I.2.1, *Methods and Tools*, the C2VSimFG model does not simulate limitations to groundwater pumping that may be imposed as part of a local GSP. Therefore, the simulated groundwater pumping values simulated by C2VSimFG may overestimate the amount of groundwater pumping in certain areas.

Table I-22. Simulated Change in Groundwater Pumping in the Central Valley for Alternative 4 Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt4 minus NAA (TAF)	Alt4 minus NAA (% Difference)
1	W, W	-9	-0.1%
2	W, W	-178	-1.5%
3	C, C	-22	-0.1%
4	C, C	45	0.2%
5	AN, W	-20	-0.2%
6	BN, AN	-191	-1.6%
7	AN, W	-61	-0.6%
8	D, D	-18	-0.1%
9	W, W	5	0.0%
10	W, W	-1	0.0%
11	W, AN	-27	-0.2%
12	D, D	-4	0.0%
13	W, W	-9	-0.1%
14	D, D	-27	-0.2%
15	C, C	181	1.2%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt4 minus NAA (TAF)	Alt4 minus NAA (% Difference)
16	D, C	28	0.2%
17	C, C	-29	-0.2%
18	C, C	55	0.3%
19	C, C	-32	-0.2%
20	AN, W	-203	-1.7%
21	C, C	-25	-0.2%
22	W, W	-10	-0.1%
23	W, W	-20	-0.2%
24	W, W	-52	-0.4%
25	W, W	7	0.1%
26	W, AN	-23	-0.2%
27	AN, AN	-215	-1.7%
28	D, D	-62	-0.4%
29	D, D	7	0.0%
30	AN, BN	41	0.3%
31	BN, D	-10	-0.1%
32	AN, W	-34	-0.3%
33	W, W	-15	-0.1%
34	D, C	11	0.1%
35	C, C	107	0.7%
36	D, BN	41	0.3%
37	BN, AN	-30	-0.2%
38	W, W	-15	-0.2%
39	BN, D	-69	-0.5%
40	D, C	125	0.8%
41	C, C	54	0.3%
42	C, C	68	0.4%
Average		**-15**	**-0.2%**
Maximum		**181**	**1.2%**
Minimum		**-215**	**-1.7%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Central Coast Region

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered by each of the alternatives. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP.

The groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water originally sourced by surface deliveries. Surface deliveries from the SWP are also in some Central Coast basins, an important support for satisfying salinity standards. In these basins, existing salinity levels in the underlying groundwater would limit its use to replace reduced surface water deliveries needed to support both sources of recharge. Without the ongoing support of groundwater recharge in this region, groundwater levels may decrease, eventually resulting in reduced groundwater production.

Southern California Region

Similar to the Central Coast Region, the C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Southern California Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP.

The groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water originally sourced by surface deliveries. Surface deliveries from the SWP are also in some Southern California basins, an important support for satisfying salinity standards. In these basins, existing salinity levels in the underlying groundwater would limit its use to replace reduced surface water deliveries needed to support both sources of recharge. Without the ongoing support of groundwater recharge in this region, groundwater levels may decrease, eventually resulting in reduced groundwater production.

I.2.6.2 Potential Changes in Groundwater-Surface Water Interaction Flow

Trinity River

Most usable groundwater in the Trinity River Region occurs in widely scattered alluvium-filled valleys, such as those immediately adjacent to the Trinity River. These valleys contain only small quantities of recoverable groundwater and therefore are not considered a major source. Given this hydrogeologic nature of this region, changes in surface water flow will likely result in little change to the groundwater-surface water interaction flow.

Central Valley

Table I-23 shows the simulated change in groundwater-surface water interaction flow in the Central Valley for Alternative 4 compared to the No Action Alternative. Alternative 4 results in an average annual change in groundwater-surface water interaction flow of 19 TAF (decrease in flow to surface water from groundwater), with a maximum single year increase in flow from groundwater to surface water of 56 TAF and a maximum single year decrease in flow from surface water to groundwater of 63 TAF. Additional groundwater-surface water interaction flow results for each of the C2VSim subregions is provided in Attachment I-1.

Table I-23. Simulated Change in Groundwater-Surface Water Interaction Flow in the Central Valley for Alternative 4 Compared to the No Action Alternative

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt4 minus NAA (TAF)	Alt4 minus NAA (% Difference)
1	W, W	-33	-21.5%
2	W, W	-9	-11.9%
3	C, C	-16	-56.7%
4	C, C	-2	-0.3%
5	AN, W	-19	-0.6%
6	BN, AN	33	4.6%
7	AN, W	-63	-5.9%
8	D, D	-42	-26.6%
9	W, W	-18	-3.4%
10	W, W	-12	-2.1%
11	W, AN	-37	-2.2%
12	D, D	-21	-2.0%
13	W, W	-9	-1.8%
14	D, D	-54	-8.1%
15	C, C	-30	-24.7%
16	D, C	4	0.6%
17	C, C	-15	-2.8%

Year	WY Type (Sacramento Valley, San Joaquin Valley)	Alt4 minus NAA (TAF)	Alt4 minus NAA (% Difference)
18	C, C	-5	-0.4%
19	C, C	52	3.3%
20	AN, W	-33	-1.7%
21	C, C	-18	-1.8%
22	W, W	-33	-1.5%
23	W, W	-34	-4.0%
24	W, W	-41	-7.2%
25	W, W	-19	-17.7%
26	W, AN	-51	-4.1%
27	AN, AN	-3	-0.5%
28	D, D	-37	-6.6%
29	D, D	-3	-4.0%
30	AN, BN	-63	-22.4%
31	BN, D	-39	-41.8%
32	AN, W	-2	-0.6%
33	W, W	-46	-32.8%
34	D, C	-9	-3.0%
35	C, C	-35	-14.1%
36	D, BN	0	0.0%
37	BN, AN	-1	-0.1%
38	W, W	-41	-4.7%
39	BN, D	-34	-35.0%
40	D, C	-11	-2.9%
41	C, C	-4	-0.4%
42	C, C	56	3.8%
Average		**-19**	**-8.7%**
Maximum		**56**	**4.6%**
Minimum		**-63**	**-56.7%**

TAF=thousand acre-feet; WY=water year.
Water Year Types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical.

Central Coast Region

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered by each of the alternatives. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

Southern California Region

Similar to the Central Coast Region, the C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Appendix H provides an analysis of potential changes in surface water supply delivered. The maximum increase in groundwater pumping would occur if it is assumed that any decrease in surface water supply delivered to the Central Coast Region would result in an equal increase in groundwater pumping assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with any existing regulatory setting such as an adjudication or GSP. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

I.2.6.3 Potential Changes in Groundwater Elevation

Trinity River

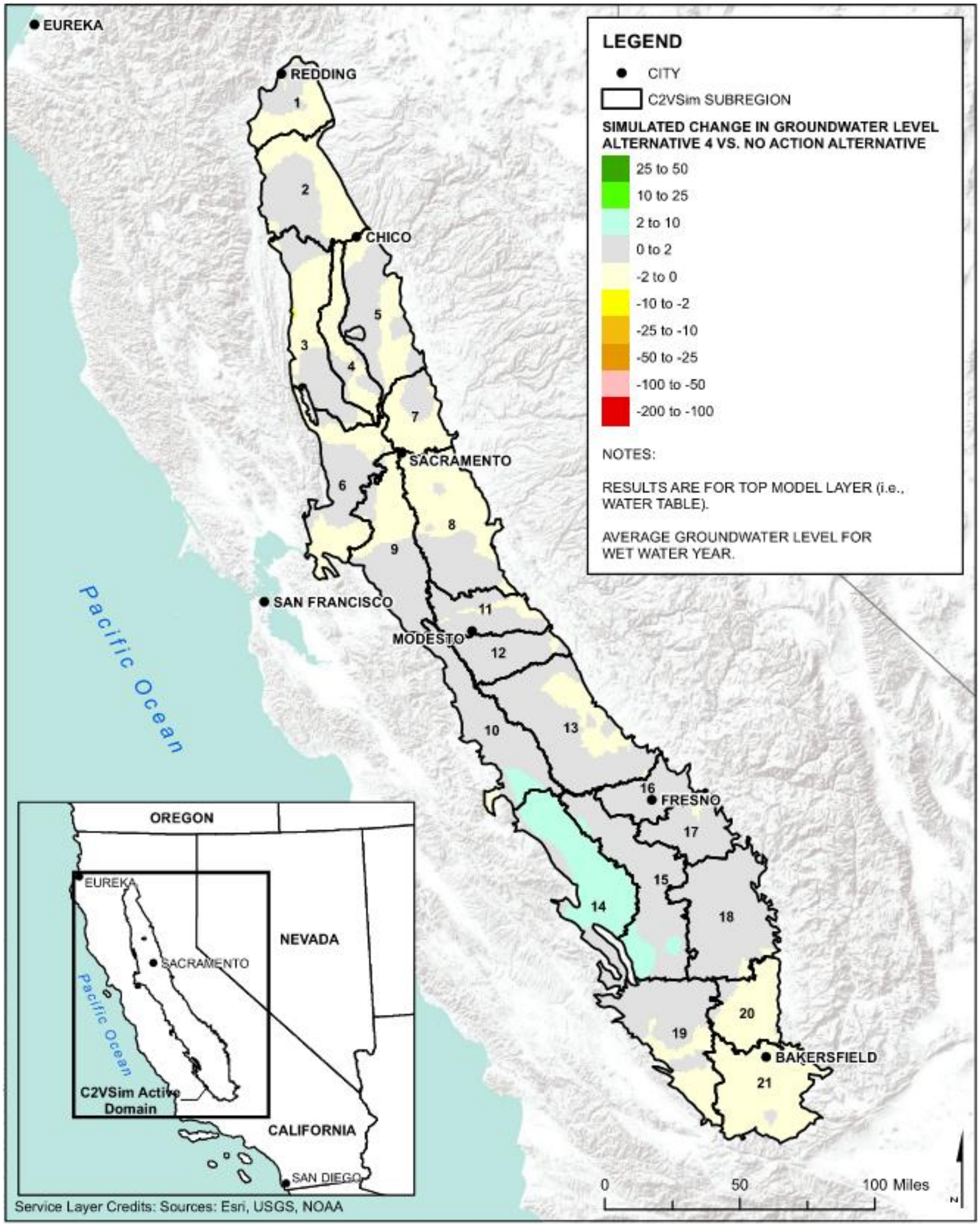
Given that there is likely to be little change to the volume of groundwater either through pumping or groundwater-surface water interaction flow, there will be little change to groundwater levels in the area.

Central Valley

The C2VSimFG groundwater model provides simulated groundwater level over the entire model simulation period for every "node" in the model (nodes cover all subregions noted in Figure I-2). Figure I-3 through Figure I-94 show the simulated change in groundwater table elevation for each node with the implementation of Alternative 4 in comparison to the No Action Alternative. The figures also show the simulation results for the other alternatives discussed in other sections.

The predicted change in groundwater table elevation for Alternative 4 as compared to the No Action Alternative spans a range from a decrease of 4.3 feet to an increase of 6.6 feet. However, note that this range of potential change captures the predicted groundwater table elevations across all 92 locations shown in the figures.

Figure I-125 through Figure I-129 show the average simulated change in groundwater table elevation for each of the five water year types defined by DWR. Table I-24 shows the range of the change in groundwater levels for Alternative 4 as compared to the No Action Alternative.



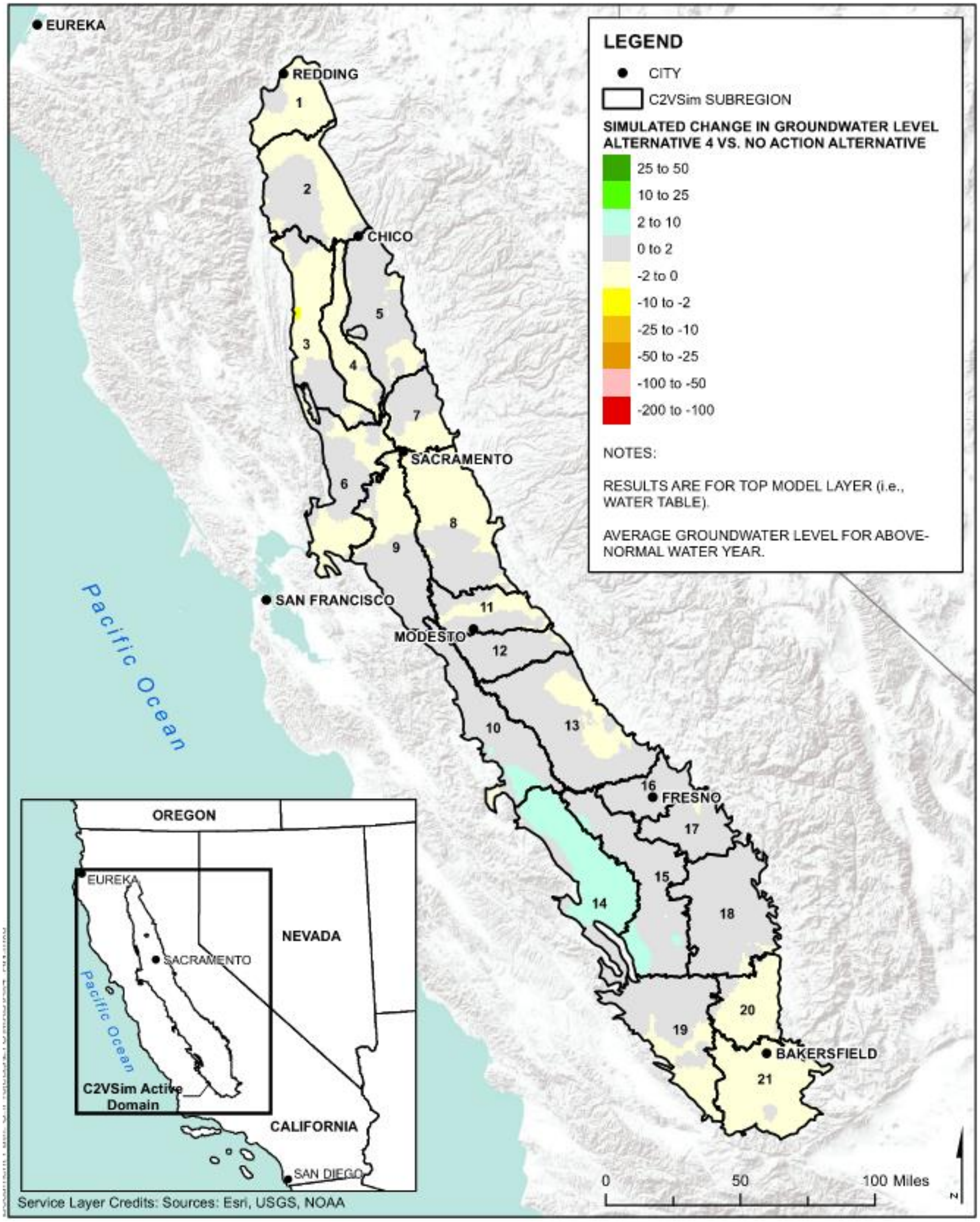
NOTES:

RESULTS ARE FOR TOP MODEL LAYER (i.e., WATER TABLE).

AVERAGE GROUNDWATER LEVEL FOR WET WATER YEAR.

Service Layer Credits: Sources: Esri, USGS, NOAA

Figure I-125. Average Simulated Change in Groundwater Table Elevation for all Wet Water Years Alternative 4 Compared to the No Action Alternative



Service Layer Credits: Sources: Esri, USGS, NOAA

Figure I-126. Average Simulated Change in Groundwater Table Elevation for all Above Normal Water Years Alternative 4 Compared to the No Action Alternative

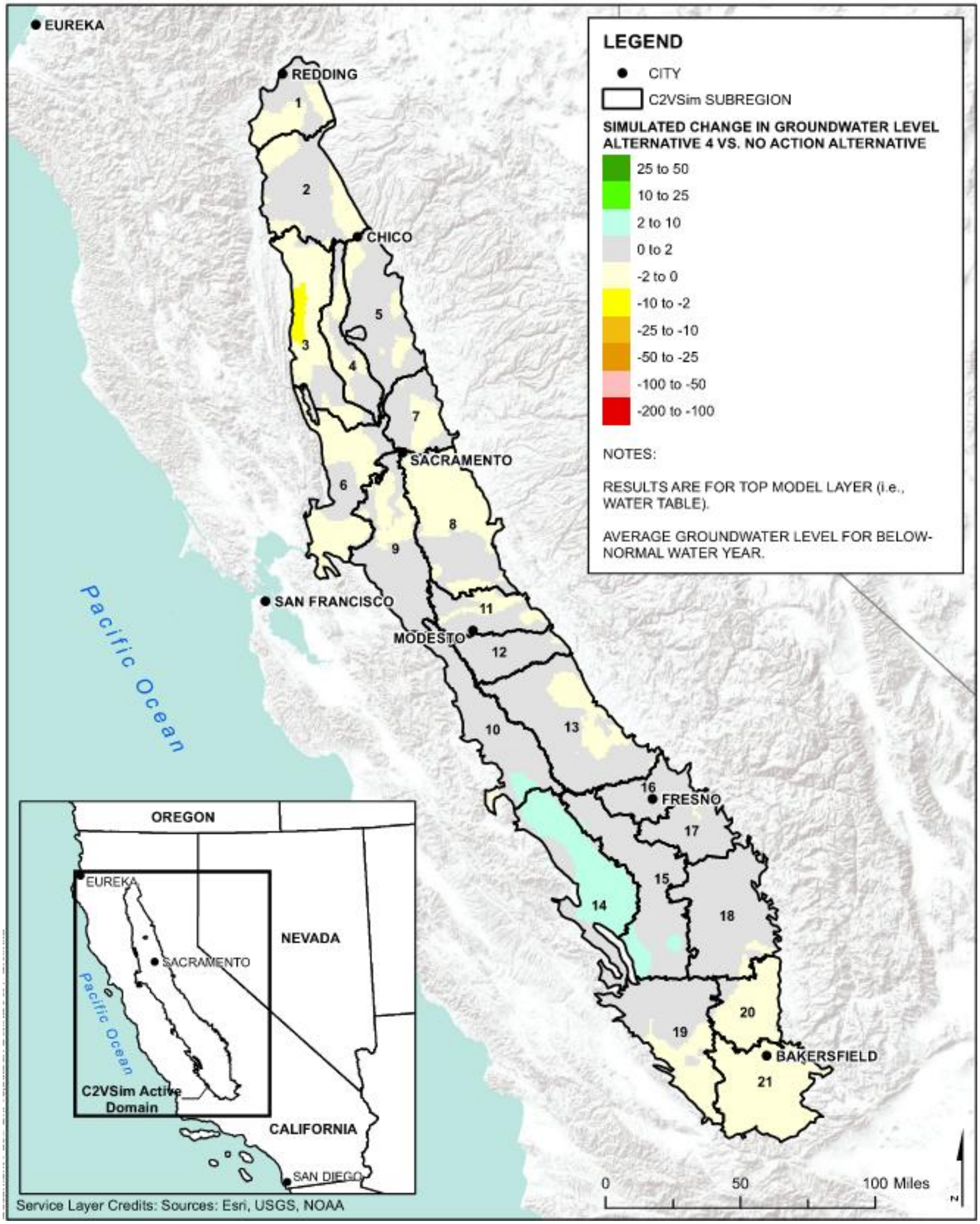


Figure I-127. Average Simulated Change in Groundwater Table Elevation for all Below Normal Water Years Alternative 4 Compared to the No Action Alternative

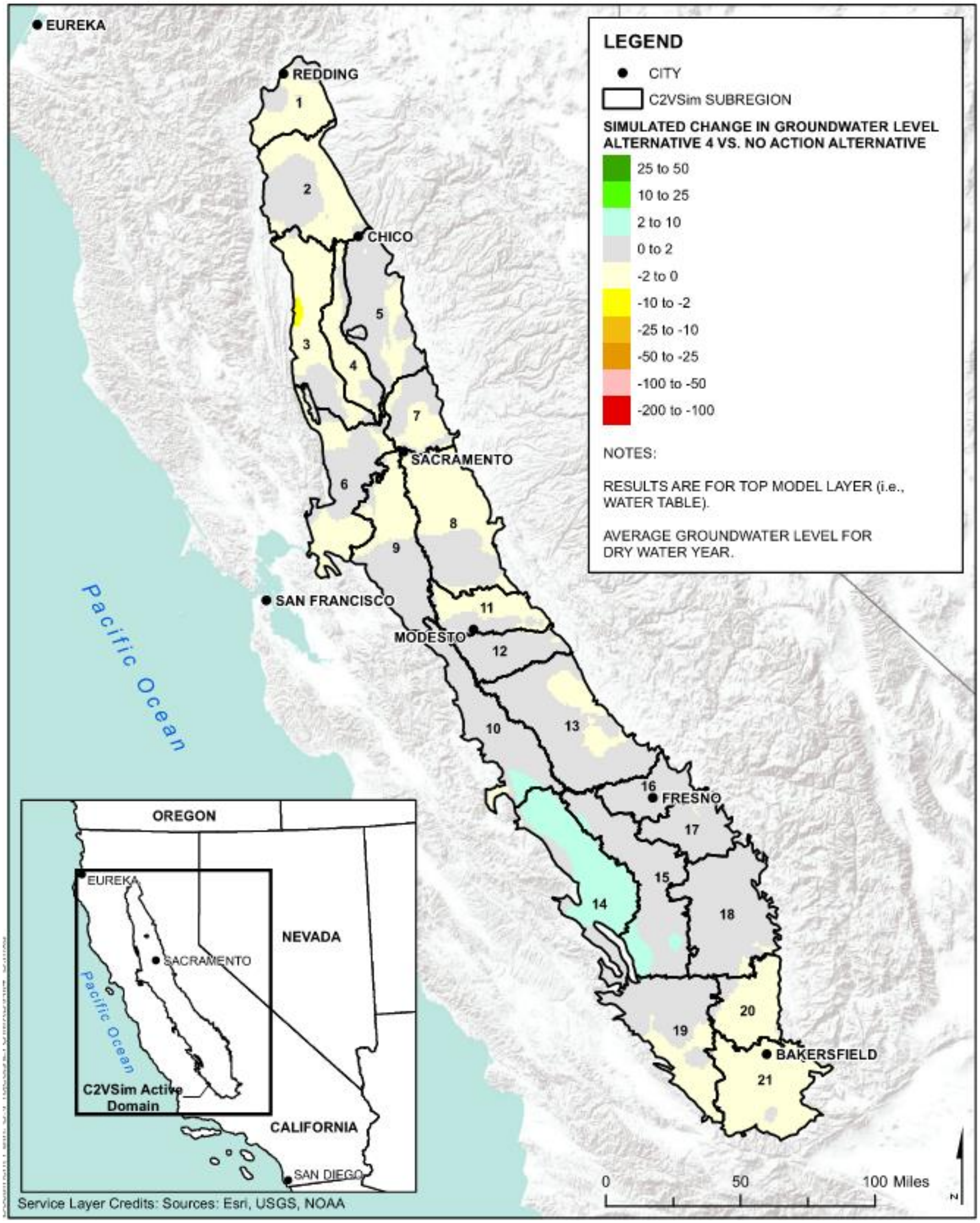


Figure I-128. Average Simulated Change in Groundwater Table Elevation for all Dry Water Years Alternative 4 Compared to the No Action Alternative

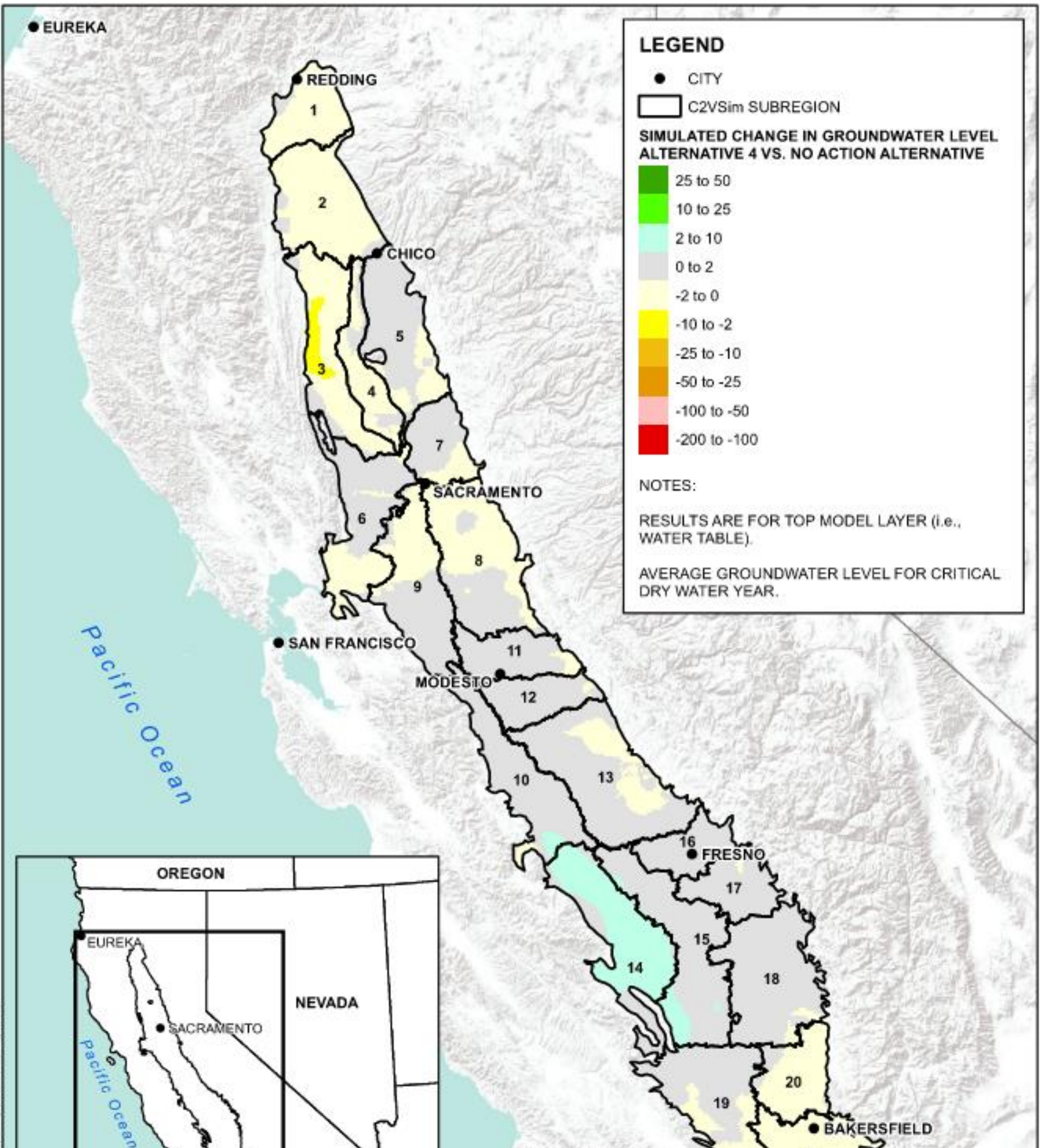


Figure I-129. Average Simulated Change in Groundwater Table Elevation for all Critical Water Years Alternative 4 Compared to the No Action Alternative

Table I-24. Simulated Change in Groundwater Table Elevation (feet) in the Central Valley for Alternative 4 Compared to the No Action Alternative for Each Water Year Type

Elevation	Wet	Above Normal	Below Normal	Dry	Critical
Average	0.2	0.2	0.2	0.2	0.2
Maximum	6.5	6.6	5.0	6.2	6.0
Minimum	-2.1	-2.2	-3.6	-2.5	-4.3

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Central Valley is not known, and therefore this impact cannot be quantified.

Central Coast Region

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The C2VSimFG model does simulate pumping in this region. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Any increase in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels. Surface water supply deliveries are discussed in Appendix H.

As discussed in the *Central Coast Region* subsection under Section I.2.6.1, groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Central Coast Region is not known, and therefore this impact cannot be quantified.

Southern California Region

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The C2VSimFG model does simulate pumping in this region. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Increases in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels. Surface water supply deliveries are discussed in Appendix H.

As discussed in *the Southern California Region* subsection under Section I.2.6.1, groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

Decreases in groundwater elevation have the potential to adversely impact groundwater pumping wells, including domestic wells, by lowering the groundwater level below the pumping elevation of the wells. The larger the decrease in groundwater level the higher the likelihood of impacts to wells. The exact location and depth of all domestic wells throughout the Southern California Region is not known, and therefore this impact cannot be quantified.

I.2.6.4 Potential Changes in Land Subsidence

Trinity River

The area along the Trinity River is not known to be susceptible to subsidence and as was noted in the *Trinity River* subsection under Section I.2.6.1, groundwater pumping is not expected to increase in this region suggesting that subsidence will not be a concern in this area. Additional information related to subsidence is available in Appendix W.

Central Valley

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. In the Sacramento and San Joaquin valleys, that reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Average groundwater levels are generally expected to decrease up to 7 feet in certain water year types under Alternative 4 compared to the No Action Alterative. The largest decreases in groundwater levels are simulated to occur along the western portion of the Central Valley in the Sacramento Valley (model subregion 3). The relatively small decreases in groundwater levels are not expected to cause large amounts of additional subsidence. However, portions of this areas are known to have historic subsidence and additional decreases in groundwater elevation may induce additional localized subsidence. The location and amount of subsidence is highly dependent on the local soil conditions and historical low groundwater levels in the area. increase or remain unchanged due to Alternative 4, it is unlikely that Alternative 4 would cause additional subsidence compared with the No Action Alternative. Additional information related to soil conditions and subsidence is available in Appendix W.

Central Coast Region

The Central Coast Region is not known to be susceptible to subsidence. However, increases in groundwater pumping may induce subsidence in areas where subsidence has not been recorded previous if groundwater levels and soil conditions allow. Additional information related to subsidence is available in Appendix W.

Southern California Region

The Southern California region is not known to be susceptible to subsidence. However, increases in groundwater pumping may induce subsidence in areas where subsidence has not been recorded previously if groundwater levels and soil conditions allow. Additional information related to subsidence is available in Appendix W.

I.2.6.5 Potential Changes in Groundwater Quality

Trinity River

Given that there is likely to be little change groundwater conditions in this region either through pumping or groundwater-surface water interaction flow, there will similarly be little change to groundwater quality in the region.

Central Valley

Groundwater quality in the Central Valley has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

Central Coast Region

Similar to the Central Valley, groundwater quality in the Central Coast Region has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. The changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

Southern California Region

Similar to the Central Valley, groundwater quality has the potential to be affected if groundwater flow patterns and elevations change due to changes in groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in either an increase or decrease in constituent concentrations depending on the local conditions and the water quality constituents present.

I.2.7 Mitigation Measures

No avoidance and minimization measures or additional mitigation measures have been identified.

I.2.8 Summary of Impacts

Table I-25 includes a summary of impacts, magnitude and direction of those impacts, and potential mitigation measures for consideration.

Table I-25. Impact Summary

Impact	Alternative	Magnitude and Direction of Impacts [a]	Potential Mitigation Measures
Potential changes in groundwater pumping	No Action	Groundwater pumping would remain similar to current conditions. [b]	--
	Alternative 1	**Trinity River:** No significant change groundwater pumping is expected. **Central Valley:** Average decrease in groundwater pumping of 138 TAF (0.9%), with a range of 343 TAF (2.4%) annual decrease to 13 TAF (0.1%) annual increase. **Southern California:** Improvements in water deliveries for all contractor types may result in reduced groundwater pumping.	--
	Alternative 2	**Trinity River:** No significant change groundwater pumping is expected. **Central Valley:** Average increase in groundwater pumping of between 19 and 59 TAF (0.1% to 0.4%) across all phases, with a range of 78 to 182 TAF (0.7% to 1.5%) annual decrease to 156 to 226 TAF (1.1% to 1.5%) annual increase. **Southern California:** No measurable change in minimum water deliveries for SWP agricultural water users and improvements in average water deliveries for SWP M&I water users may result in reduced groundwater pumping.	--
	Alternative 3	**Trinity River:** No significant change groundwater pumping is expected. **Central Valley:** Average increase in groundwater pumping of 626 TAF (4.9%), with a range of annual increases from 74 to 920 TAF (0.4% to 7.8%) annual increase. **Southern California:** A 54% reduction in average deliveries to SWP M&I water users may result in increased groundwater pumping to offset the loss of supply.	--

Impact	Alternative	Magnitude and Direction of Impacts [a]	Potential Mitigation Measures
	Alternative 4	**Trinity River:** No significant change groundwater pumping is expected. **Central Valley:** Average decrease in groundwater pumping of 15 TAF (0.2%), with a range of 215 TAF (1.7%) annual decrease to 181 TAF (1.2%) annual increase. **Southern California:** No measurable change in SWP agricultural deliveries and improvements in average water deliveries for SWP M&I water users may result in a decrease in groundwater pumping.	--
Potential changes in groundwater-surface water interaction flow	No Action	Groundwater-surface water interaction flow would remain similar to current conditions. [b]	--
	Alternative 1	**Trinity River:** No significant change groundwater-surface water interaction flow is expected. **Central Valley:** Average decrease in flow from groundwater to surface water of 116 TAF (44.8%), with a range of 194 TAF (206.1%) annual decrease to 54 TAF (3.2%) annual increase. **Southern California:** Improvements in water deliveries for all contractor types may result in reduced groundwater pumping and reduced discharge surface water to groundwater.	--
	Alternative 2	**Trinity River:** No significant change groundwater pumping is expected. **Central Valley:** Average increase in flow from groundwater to surface water of between 17 and 69 TAF (2.0% to 9.1%) across all phases, with a range of 12 to 16 TAF (0.7% to 11.6%) annual decrease to 126 to 199 TAF (25.3% to 170.8%) annual increase. **Southern California:** No measurable change in minimum water deliveries for SWP agricultural water users and improvements in average water deliveries for SWP M&I water users may result in reduced groundwater pumping.	--
	Alternative 3	**Trinity River:** No significant change groundwater pumping is expected. **Central Valley:** Average increase in flow from groundwater to surface water of 455 TAF (173.2%), with a range of 245 TAF (12.7%) annual increase to 809 TAF (1301.7%) annual increase.	--

Impact	Alternative	Magnitude and Direction of Impacts [a]	Potential Mitigation Measures
		Southern California: A 54% reduction in average deliveries to SWP M&I water users may result in increased groundwater pumping to offset the loss of supply and, therefore, have the potential to increase discharge of surface water to groundwater.	
	Alternative 4	**Trinity River:** No significant change groundwater pumping is expected. **Central Valley:** Average decrease in flow from groundwater to surface water of 19 TAF (8.7%), with a range of 63 TAF (56.7%) annual decrease to 56 TAF (4.6%) annual increase. **Southern California:** No measurable change in SWP agricultural deliveries and improvements in average water deliveries for SWP M&I water users may result in a decrease in groundwater pumping and reduced discharge surface water to groundwater.	--
Potential changes in groundwater elevation	No Action	Groundwater elevations would remain similar to current conditions. [b]	--
	Alternative 1	**Trinity River:** No significant change groundwater elevation is expected. **Central Valley:** The range of average groundwater level change for each Water Year type is: • *Wet:* -0.6 to 32.6 feet • *Above Normal:* -0.6 to 31.0 feet • *Below Normal:* -1.4 to 29.9 feet • *Dry:* -0.9 to 30.7 feet • *Critical:* -1.2 to 32.5 feet **Southern California:** Improvements in water deliveries for all contractor types may result in reduced groundwater pumping and increased groundwater elevations.	--

	Alternative 2	**Trinity River:** No significant change groundwater elevation is expected.
		Central Valley: The range of average groundwater level change for each Water Year type is:
		• Alternative 2 With TUCP Without VA
		  • *Wet:* -9.6 to 2.9 feet
		  • *Above Normal:* -9.1 to 3.0 feet
		  • *Below Normal:* -9.4 to 2.2 feet
		  • *Dry:* -10.0 to 2.3 feet
		  • *Critical:* -12.7 to 1.8 feet
			--

Impact	Alternative	Magnitude and Direction of Impacts [a]	Potential Mitigation Measures

		• Alternative 2 Without TUCP Without VA
		  • *Wet:* -11.9 to 2.7 feet
		  • *Above Normal:* -10.9 to 2.7 feet
		  • *Below Normal:* -12.4 to 1.2 feet
		  • *Dry:* -12.1 to 1.9 feet
		  • *Critical:* -13.8 to 2.0 feet
		• Alternative 2 Without TUCP Delta VA
		  • *Wet:* -18.6 to 4.0 feet
		  • *Above Normal:* -16.8 to 3.9 feet
		  • *Below Normal:* -15.8 to 1.6 feet
		  • *Dry:* -16.8 to 1.5 feet
		  • *Critical:* -17.5 to 2.6 feet
		• Alternative 2 Without TUCP Systemwide VA
		  • *Wet:* -18.1 to 2.3 feet
		  • *Above Normal:* -16.1 to 2.6 feet
		  • *Below Normal:* -17.7 to 1.0 feet
		  • *Dry:* -17.4 to 0.9 feet
		  • *Critical:* -19.5 to 1.4 feet
		Southern California: No measurable change in minimum water deliveries for SWP agricultural water users and improvements in average water deliveries for SWP M&I water users may result in reduced groundwater pumping and increased groundwater elevations.	

	Alternative 3	**Trinity River:** No significant change groundwater elevation is expected. **Central Valley:** The range of average groundwater level change for each Water Year type is: • *Wet:* -158.6 to 0.5 feet • *Above Normal:* -145.9 to 0.7 feet • *Below Normal:* -125.0 to 0.5 feet • *Dry:* -143.7 to 0.7 feet • *Critical:* -155.2 to 2.4 feet **Southern California:** A 54% reduction in average deliveries to SWP M&I water users may result in increased groundwater pumping to offset the loss of supply and, therefore, have the potential to increase groundwater pumping and, therefore, lower groundwater elevations.	--
	Alternative 4	**Trinity River:** No significant change groundwater pumping is expected.	--

Impact	Alternative	Magnitude and Direction of Impacts [a]	Potential Mitigation Measures
		Central Valley: The range of average groundwater level change for each Water Year type is: • *Wet:* -2.1 to 6.5 feet • *Above Normal:* -2.2 to 6.6 feet • *Below Normal:* -3.6 to 5.0 feet • *Dry:* -3.5 to 6.2 feet • *Critical:* -4.3 to 6.0 feet **Southern California:** No measurable change in SWP agricultural deliveries and improvements in average water deliveries for SWP M&I water users may result in a decrease in groundwater pumping and increased in groundwater elevation.	
Potential changes in land subsidence	No Action	Land subsidence would remain similar to current conditions. [b]	--
	Alternative 1	**Trinity River:** No significant change groundwater pumping is expected and, therefore, no pronounced land subsidence is expected. **Central Valley:** On average, a decrease in groundwater pumping would not result in an increase in land subsidence, However, localized increases in groundwater pumping may increase the potential for land subsidence depending on local geologic conditions. **Southern California:** Improvements in water deliveries for all contractor types may result in reduced groundwater pumping and, therefore, the potential for land subsidence is low.	--
	Alternative 2	**Trinity River:** No significant change groundwater pumping is expected and, therefore, no pronounced land subsidence is expected. **Central Valley:** Average groundwater levels are simulated to decrease up to approximately 12 feet for Alternative 2 With TUCP Without VA and Alternative 2 Without TUCP Without VA in some water year types. Groundwater levels may decrease closer to 20 feet for Alternative 2 Without TUCP Delta VA and Alternative 2 Without TUCP Systemwide VA. Alternatives with larger decreases in groundwater levels have as higher likelihood of causes additional subsidence. Portions of the areas with larger decreases in groundwater elevation are known to have historic subsidence and further reductions in groundwater level may cause additional subsidence.	--

Impact	Alternative	Magnitude and Direction of Impacts [a]	Potential Mitigation Measures
		Southern California: No measurable change in minimum water deliveries for SWP agricultural water users and improvements in average water deliveries for SWP M&I water users may result in reduced groundwater pumping and, therefore, the potential for land subsidence is low.	
	Alternative 3	**Trinity River:** No significant change groundwater pumping is expected and, therefore, no pronounced land subsidence is expected. **Central Valley:** Average groundwater levels are simulated to decrease up to approximately 160 feet for Alternative 3 in some water year types compared to the No Action Alternative. The largest decreases in groundwater levels are simulated to occur along the western portion of the Central Valley in the Sacramento Valley and in the San Joaquin Valley. Given the relatively large decreases in groundwater elevations and the fact that portions of these areas are known to have historic subsidence, the potential for additional subsidence is high. **Southern California:** A 54% reduction in average deliveries to SWP M&I water users may result in increased groundwater pumping to offset the loss of supply and, therefore increase the potential for land subsidence depending on local geologic conditions.	--
	Alternative 4	**Trinity River:** No significant change groundwater pumping is expected and, therefore, no pronounced land subsidence is expected. **Central Valley:** Average groundwater levels are simulated to decrease up to approximately 7 feet for Alternative 4 in some water year types compared to the No Action Alternative. The largest decreases in groundwater levels are simulated to occur along the western portion of the Central Valley in the Sacramento Valley. The relatively small decreases in groundwater levels are not expected to cause large amounts of additional subsidence. However, portions of these areas are known to have historic subsidence and additional decreases in groundwater elevation may induce additional localized subsidence. **Southern California:** No measurable change in SWP agricultural deliveries and improvements in average water deliveries for SWP M&I water users may result in a decrease in groundwater pumping and, therefore, the potential for land subsidence is low.	--

Impact	Alternative	Magnitude and Direction of Impacts [a]	Potential Mitigation Measures
Potential changes in groundwater quality	No Action Alternative	Groundwater quality would remain similar to current conditions. [b]	--
	Alternative 1	The concentration of constituents in groundwater may increase or decrease locally based on local changes to groundwater pumping patterns and the constituents present.	--
	Alternative 2	The concentration of constituents in groundwater may increase or decrease locally based on local changes to groundwater pumping patterns and the constituents present.	--
	Alternative 3	The concentration of constituents in groundwater may increase or decrease locally based on local changes to groundwater pumping patterns and the constituents present.	--
	Alternative 4	The concentration of constituents in groundwater may increase or decrease locally based on local changes to groundwater pumping patterns and the constituents present.	--

M&I = municipal and industrial; SWP = State Water Project; TAF = thousand acre-feet.

[a] For the evaluation of alternatives, operation of the action alternatives is compared to the No Action Alternative.

[b] Under the No Action Alternative, Reclamation would operate the CVP consistent with the 2020 Record of Decision implementing the Proposed Action consulted upon for the 2019 Biological Opinions and the reasonable and prudent measures in the incidental take statements. DWR would operate the SWP consistent with the 2020 Record of Decision and the 2020 Incidental Take Permit for the SWP. Reclamation and DWR would operate consistent with authorizing legislation, water rights, contracts, and agreements as described by common components. The evaluation under the No Action Alternative is compared to existing conditions. Alternatives are compared to the No Action Alternative

I.2.9 Cumulative Impacts

Past, present, and reasonably foreseeable projects, described in Appendix Y, *Cumulative Impacts Technical Appendix*, may have cumulative effects on groundwater resources, to the extent that they could change groundwater pumping, groundwater-surface water interaction, groundwater elevation, land subsidence, and groundwater quality.

Reasonably foreseeable projects include actions across California to develop water storage capacity, water conveyance infrastructure, water recycling capacity, and the reoperation of existing water supply infrastructure, including surface water reservoirs and conveyance infrastructure. The projects identified in Appendix Y that have the potential to contribute to the cumulative impact on water supply are related to:

- Del Puerto Canyon Reservoir
- Delta Conveyance Project
- Pacheco Reservoir/San Luis Low Point Improvement Project
- Eastern San Joaquin Integrated Conjunctive Use Program

The No Action Alternative would continue with current operations of the CVP and is not expected to result in changes to groundwater pumping, groundwater-surface water interaction, groundwater elevation, land subsidence, and groundwater quality. Therefore, cumulative impacts to groundwater resources are not expected under the No Action Alternative.

I.2.9.1 Changes in Groundwater Pumping

Alternative 1 would generally result in an increase in surface water supplies and a corresponding reduction in groundwater pumping. Because of this potentially beneficial effect on groundwater by reducing pumping, Alternative 1 would not contribute to cumulative impacts on groundwater resources. In the case of cumulative impacts from projects listed in Appendix Y that may potentially generate temporary reductions in water supply deliveries or reduce surplus water supply availability to neighboring water users, Alternative 1's reduction in groundwater pumping would help to reduce the severity of any potential cumulative effect. Alternatives 2 and 4 would have similar effects as Alternative 1 and would not contribute to cumulative impacts from groundwater pumping.

Alternative 3 would generally result in a decrease in surface water supplies and a corresponding estimated increase in groundwater pumping of 4.9%. Because of the increase in groundwater pumping when compared to the No Action Alternative, Alternative 3 would be anticipated to contribute to cumulative impacts on groundwater by increasing pumping. However, when considered with the projects listed in Appendix Y, Alternative 3's contribution to cumulative impacts on groundwater resources is anticipated to be minimal.

I.2.9.2 Potential Changes in Groundwater Elevation

Alternative 1 would generally decrease the amount of groundwater pumping due to an increase in surface water supplies available to CVP and SWP contractors. The decrease in groundwater pumping would result in an increase in groundwater elevations. Because Alternative 1's contribution to groundwater pumping conditions is anticipated to be minor, Alternative 1's contribution to cumulative changes in groundwater elevation is also expected to be minor. Alternatives 2 and 4 would have similar effects as Alternative 1 and would not be expected to result in contributions to cumulative groundwater elevations as only a minimal increase in groundwater pumping under these alternatives is anticipated.

Alternative 3 would increase the average amount of annual groundwater pumping by approximately 4.9% due to a decrease in surface water supplies available to CVP and SWP contractors. The increase in groundwater pumping would result in a decrease in groundwater elevations. Alternative 3's contribution to cumulative changes in groundwater elevation would be larger in certain areas than for Alternatives 1, 2, and 4. However, Alternative 3's contribution to cumulative changes in groundwater elevation is expected to be minimal.

I.2.9.3 Potential Changes in Groundwater-Surface Water Interaction

Alternatives 1, 2, and 4 would generally change the amount of groundwater that discharges annually to surface water by less than 1.2% on average due to a change in surface water supplies available to CVP and SWP contractors. Because this change is considered small, Alternative 1, 2, and 4's contribution to cumulative changes in groundwater elevation is expected to be minimal. Alternative 3 would have similar effects as Alternative 1 however the average change would be an increase in the loss from surface water of approximately 4.7%. Similar to Alternatives 1, 2, and 4, this change is considered small and may result in minimal contributions to cumulative impacts on groundwater-surface water interactions.

I.2.9.4 Potential Changes in Land Subsidence

Alternative 1's contribution to groundwater pumping conditions is expected to be minimal; therefore, Alternative 1's contribution to cumulative changes in groundwater elevation is also expected to be minimal (average decrease in pumpoing of 0.9%). Without a substantial change to groundwater elevations, there would also not be a substantial change to land subsidence. Alternatives 2 and 4 would have similar effects as Alternative 1 (less than a 0.4% average increase for Alternative 2 and average decrease 0.2% for Alternative 4) and would not be anticipated to contribute to cumulative impacts resulting in land subsidence. An increase in pumping, if occurring in areas susceptible to subsidence, may result in additional subsidence.

Alternative 3 has the potential to increase groundwater pumping by approximately 4.9%. An increase in pumping, if occurring in areas susceptible to subsidence, may result in additional subsidence. Average groundwater levels are simulated to decrease up to approximately 160 feet for Alternative 3 in some water year types compared to the No Action Alternative. The largest decreases in groundwater levels are simulated to occur along the western portion of the Central Valley in the Sacramento Valley and in the San Joaquin Valley. Additional areas of decreased groundwater levels appear north of Modesto and south of Fresno. Given the relatively large decreases in groundwater elevations and the fact that portions of these areas are known to have historic subsidence, the potential for additional subsidence is high. The location and amount of subsidence is highly dependent on the local soil conditions and historical low groundwater levels in the area. Alternative 3's may contribute to cumulative impacts resulting in subsidence, depending on the local geologic conditions.

I.2.9.5 Potential Changes in Groundwater Quality

Alternative 1's contribution to groundwater pumping conditions is not expected to be substantial; therefore, Alternative 1's contribution to cumulative changes in groundwater elevation is also not expected to be substantial. Without a substantial change to groundwater elevations, there would also not be a substantial change to groundwater quality. Alternatives 2 and 4 would have similar effects as Alternative 1 (less than a 1.2% increase) and may result in minimal contributions to cumulative impacts related to groundwater quality. An increase in pumping, if occurring where groundwater quality concerns exist, may result in changes to groundwater flow patterns and change the movement of constituents in groundwater.

Alternative 3 has the potential to increase groundwater pumping by approximately 4.9%. An increase in pumping, if occurring where groundwater quality concerns exist, may result in changes to groundwater flow patterns and change the movement of constituents in groundwater.

However, Alternative 3's overall the effect on groundwater pumping when considered with the projects identified in Appendix Y, would be expected to result in a minimal cumulative impacts on groundwater quality.

I.3 References

Alameda County Water District. 2012. *Survey Report on Groundwater Conditions.* February. Available: https://web.archive.org/web/20120307224007/http://www.acwd.org/engineering/groundwater_docs/Survey%20Report.pdf. Accessed: May 15, 2024.

Beaumont Basin Watermaster. 2013. *Annual Report for Calendar Year 2012.* December. Available: http://documents.yvwd.dst.ca.us/bbwm/documents/2012annualreport140100.pdf. Accessed: May 15, 2024.

Berkstresser, C. F. Jr. 1973. Base of Fresh Ground-Water – Approximately 3,000 micromhos – in the Sacramento Valley and Sacramento-San Joaquin Delta, California. *U.S. Geological Survey Water-Resource Inv.* 40–73. Available: https://pubs.usgs.gov/publication/wri7340. Accessed: May 15, 2024.

Bureau of Reclamation. 2010. *Resighini Rancheria Water Resources Development Project, Environmental Assessment.* July.

Bureau of Reclamation and California Department of Water Resources. 2012. *San Joaquin River Restoration Program, Final Program Environmental Impact Statement/Environmental Impact Report.* July. Available: https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=2940. Accessed: May 15, 2024.

Bureau of Reclamation, Bureau of Land Management, and Trinity County Planning Department. 2006. *Indian Creek Rehabilitation Site: Trinity River Mile 93.7 to 96.5, Environmental Assessment/Draft Environmental Impact Report.* July. Available: https://www.trrp.net/library/document/?id=2118. Accessed: May 15, 2024.

Butte County. 2004. *Butte County Groundwater Management Plan.* September.

Butte County. 2010. *General Plan Draft Environmental Impact Report.* April 8.

California Department of Water Resources. 2003. *California's Groundwater, Bulletin 118 Update.* October 1.

California Department of Water Resources. 2004. *California's Groundwater, Bulletin 118 Update.* February 27.

California Department of Water Resources. 2006. *California's Groundwater, Bulletin 118 Update.* January 20.

California Department of Water Resources. 2010. *Water Use Efficiency Data Portal: 2010 Urban Water Management Plans.* Available: https://wuedata.water.ca.gov/. Accessed: May 16, 2024.

California Department of Water Resources. 2013. *California Water Plan Update 2013.* Available: https://web.archive.org/web/20140101001827/http://www.waterplan.water.ca.gov/cwpu2013/prd/index.cfm. Accessed: May 15, 2024.

California Department of Water Resources. 2014a. *Public Update for Drought Response, Groundwater Basins with Potential Water Shortages, Gaps in Groundwater Monitoring, Monitoring of Land Subsidence, and Agricultural Land Fallowing.* November. Available: https://www.rcrcnet.org/sites/default/files/documents/DWR_PublicUpdateforDroughtResponse_GroundwaterBasins.pdf. Accessed: May 16, 2024.

California Department of Water Resources. 2014b. *Public Update for Drought Response, Groundwater Basins with Potential Water Shortages and Gaps in Groundwater Monitoring.* April 30. Available: https://digitalcommons.csumb.edu/cgi/viewcontent.cgi?article=1065&context=hornbeck_usa_3_d. Accessed: May 16, 2024.

California Department of Water Resources. 2014c. *Groundwater Management: Court Adjudications.* Available: https://web.archive.org/web/20140401223244/http://www.water.ca.gov/groundwater/gwmanagement/court_adjudications.cfm. Accessed: May 16, 2024.

California Department of Water Resources. 2015. California's Groundwater Update 2013. April.

California Department of Water Resources. 2018. *2017 GPS Survey of the Sacramento Valley Subsidence Network.* December. Available: https://web.archive.org/web/20220121201640/http://www.yolowra.org/documents/2017_GPS_Survey_of_the_Sacramento_Valley_Subsidence_Network.pdf. Accessed: May 16, 2024.

California Department of Water Resources. 2019. *Finalizes Groundwater Basin Boundary Modifications under SGMA.* February 11. Available: https://water.ca.gov/News/News-Releases/2019/February/Final-Basin-Boundary-Modifications-Released. Accessed: May 15, 2024.

California Department of Water Resources. 2020. *Sustainable Groundwater Management Act 2019 Basin Prioritization.* May. Available: https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization#:~:text=Basin%20Prioritization%20is%20a%20technical%20process%20that%20utilizes,in%20the%20California%20Water%20Code%20Section%2010933%20%28b%29 (see Current SGMA Basin Prioritization Process and Results Document). Accessed: March 31, 2023.

California Department of Water Resources. 2021a. *California's Groundwater Update 2020.* Available: https://data.cnra.ca.gov/dataset/3f87088d-a2f9-4a46-a979-1120069db2c6/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be/download/calgw2020_full_report.pdf. Accessed: March 28, 2023.

California Department of Water Resources. 2021b. *Groundwater Conditions Report Water Year 2021.* Available: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Statewide-Reports/Groundwater-Conditions-Report-Fall-2021.pdf. Accessed: March 18, 2023.

California Department of Water Resources. 2023. *SGMA Data Viewer.* Available: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels. Accessed: March 29, 2023.

California Department of Water Resources. 2024. Groundwater Well Permitting, Observations and Analysis of Executive Orders N-7-22 and N-3-23. Available: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Wells/Files/DWR-Well-Permitting-Analysis-Final_March2024.pdf. Accessed: April 4, 2024.

California Water Boards. 2021. *General Orders.* Available: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/. Accessed: March 18, 2023.

Camrosa Water District. 2013. *Santa Rosa Basin Groundwater Management Plan.* August. Available: https://www.camrosa.com/wp-content/uploads/2017/09/gmp-092013-final.pdf. Accessed: May 16, 2024.

Castaic Lake Water Agency, Santa Clarita Water Division, Los Angeles County Waterworks District 36, Newhall County Water District, and Valencia Water Company. 2012. *14th Annual Santa Clarita Valley Water Report 2011.* June.

Central Coast Water Authority. 2013. *Central Coast Water Authority fiscal year 2013/14 Budget.* April 25. Available: https://www.ccwa.com/files/93aa935bb/FY2013-14Budget.pdf. Accessed: May 15, 2024.

Central Valley Regional Water Quality Control Board. 2011. *Irrigated Lands Regulatory Program, Program Environmental Impact Report.* March. Available: https://www.waterboards.ca.gov/rwqcb5/water_issues/irrigated_lands/regulatory_information/program_environmental_impact_report/. Accessed: May 16, 2024.

Central Valley Regional Water Quality Control Board. 2014. *Order R5-2014-0029, Waste Discharge Requirements General Order for Growers within the San Joaquin County and Delta Area That are Members of a Third-Party Group.* March. Available: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2014-0029-06.pdf. Accessed: May 16, 2024.

City of Castro Valley. 2012. *Castro Valley General Plan.* March. Available: https://www.acgov.org/cda/planning/generalplans/documents/CastroValleyGeneralPlan_2012_FINAL.pdf. Accessed: May 16, 2024.

City of Firebaugh. 2015. *2030 Firebaugh General Plan.* Available: https://web.archive.org/web/20150619115839/http://www.ci.firebaugh.ca.us/general-plan.shtml. Accessed: May 16, 2024.

City of Long Beach. 2012. *Long Beach 90H20.* January.

City of Mendota. 2009. *City of Mendota General Plan Update 2005-2025.* August 11.

City of Monterey Park. 2012. *Water System Financial Evaluations and Water Rate Recommendations.* September 17. Available: https://www.montereypark.ca.gov/DocumentCenter/View/1052/2012-Water-Rate-Study-PDF?bidId=. Accessed: May 16, 2024.

City of Norco. 2014. *Welcome to the Public Works Department, Water Maintenance Division.* Available: http://www.ci.norco.ca.us/depts/pw/default.asp. Accessed: July 17, 2014.

City of Patterson. 2014. *The City of Patterson, Water Operations, 2012 Annual CCR Report.* Accessed: May 6, 2014.

City of Roseville, Placer County Water Agency, City of Lincoln, California American Water Company. 2007. *Western Placer County Groundwater Management Plan.* November. Available: https://cdn.cosmicjs.com/ed265ac0-70b7-11e8-b89a-91a6fa50a41c-WPCGMP_Groundwater_Management_Plan_07.pdf. Accessed: May 16, 2024.

Coachella Valley Water District. 2012. *Coachella Valley Water Management Plan Update, Final Report.* January. Available: https://www.cvwd.org/DocumentCenter/View/1291/Final-SPEIR-for-the-2010-Coachella-Valley-Water-Management-Plan-UpdatePDF?bidId=. Accessed: May 16, 2024.

Contra Costa County. 2005. *Contra Costa County General Plan, 2005-2020.* January. Available: https://web.archive.org/web/20151009152807/https://www.contracosta.ca.gov/4732/General-Plan. Accessed: May 16, 2024.

Contra Costa Water District. 2017. *Water Management Plan.* Available: https://www.ccwater.com/DocumentCenter/View/3881/2017-Water-Management-Plan-PDF. Accessed: March 17, 2023.

East Bay Municipal Utility District. 2013. *South East Bay Plain Basin Groundwater Management Plan.* March. Available: https://www.ebmud.com/about-us/construction-and-maintenance/construction-my-neighborhood/south-east-bay-plain-basin-groundwater-management. Accessed: May 16, 2024.

Eastern Municipal Water District. 2009. *Executive Summary Substitute Environmental Document Basin Plan Amendment San Jacinto–Upper Pressure Groundwater Management Zone Total Dissolved Solids and Total Inorganic Nitrogen Objectives.* November. Available: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=65f5adc26be09a3ec51cf703df84b8a0f5784d4c. Accessed: May 16, 2024.

Eastern Municipal Water District. 2014. *Hemet/San Jacinto Groundwater Management Area, 2013 Annual Report, Prepared for Hemet-San Jacinto Watermaster.* April.

Eastern San Joaquin County Groundwater Basin Authority. 2004. *Eastern San Joaquin Groundwater Basin Groundwater Management Plan.* Available: https://www.sjgov.org/docs/default-source/public-works-documents/water-resources/final-eastern-san-joaquin-groundwater-basin-groundwater-management-plan.pdf?Status=Master&sfvrsn=df184243_3. Accessed: May 16, 2024.

Eastern San Joaquin County Groundwater Basin Authority. 2007. *Integrated Regional Water Management Plan.* Available: https://www.gbawater.org/Portals/0/assets/docs/GBA_IRWMP.pdf. Accessed: May 16, 2024.

Farmington Program. 2012. *Overview.* Available: http://www.farmingtonprogram.org/about.html. Accessed: November 30, 2012.

Fox Canyon Groundwater Management Agency. 2013. *Annual Report for Calendar Year 2012.* Available: https://s42135.pcdn.co/wp-content/uploads/2024/03/2012-FCGMA-Annual-Report.pdf. Accessed: May 16, 2024.

Frame Surveying and Mapping. 2006. *The Yolo County GPS Subsidence Network Recommendations and Continued Monitoring.* March. Available: https://www.yologroundwater.org/files/ed9b2164e/7%29+YSN2005+Final+Report.pdf. Accessed: May 16, 2024.

Fresno County. 2000. *Fresno County General Plan Background Report.* October.

Goleta Water District and La Cumbre Mutual Water Company. 2010. *Groundwater Management Plan–Goleta Groundwater Basin – Final.* May. Available: https://www.goletawater.com/doc/1194/. Accessed: May 16, 2024.

Greater Los Angeles County Integrated Regional Water Management Region. 2014. *The Greater Los Angeles County Integrated Regional Water Management Plan.* February. Available: https://dpw.lacounty.gov/wmd/irwmp/FileList.aspx?path=docs\2014%20Public%20IRWMP%20Update. Accessed: May 16, 2024.

Hoopa Valley Tribe. 2008. *Water Quality Control Plan, Hoopa Valley Indian Reservation.* February. Available: https://cawaterlibrary.net/wp-content/uploads/2017/10/Hoopa-valley-tribe-water-quality-control-plan.pdf. Accessed: May 16, 2024.

Ikehara, M. E. 1994. Global Positioning System Surveying to Monitor Land Subsidence in Sacramento Valley, California, USA. *Hydrological Sciences Journal.* Volume 29 (5)

La Habra Heights County Water District. 2012. *2011 Water Master Plan Update.* March.

Los Angeles County Department of Public Works. 2014. *Los Angeles County Waterworks Districts.* Available: https://web.archive.org/web/20140713213101/http://dpw.lacounty.gov/wwd/web/About/Overview.aspx. Accessed: May 16, 2024..

Los Angeles County Department of Public Works. 2015. *San Gabriel River and Montebello Forebay Water Conservation System.* Available: https://web.archive.org/web/20170226103906/http://ladpw.org/wrd/publication/system/downstream.cfm. Accessed: May 16, 2024.

Madera County. 2002. *AB3030 Groundwater Management Plan, Madera County, Final Draft.* January.

Madera County. 2008. *Integrated Regional Water Management Plan.* April. Available: https://www.maderacountywater.com/wp-content/uploads/2019/05/1-49.pdf. Accessed: May 16, 2024.

Merced County. 2012. *Merced County General Plan Revised Background Report.* November. Available: https://www.countyofmerced.com/1926/Draft-General-Plan-Draft-Program-EIR. Accessed: May 16, 2024.

Metropolitan Water District of Southern California. 2007. *Groundwater Assessment Study.* September.

North Coast Regional Water Quality Control Board and Bureau of Reclamation. 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment.* June. Available: https://www.trrp.net/DataPort/doc.php?id=476. Accessed: May 15, 2024.

North Coast Regional Water Quality Control Board. 2005. *Integrated Plan for Implementation of the Watershed Management Initiative–Watershed Planning Chapter.* February.

Northeastern San Joaquin County Groundwater Banking Authority. 2004. *Eastern San Joaquin Groundwater Basin Groundwater Management Plan.* September. Available: https://www.sjgov.org/docs/default-source/public-works-documents/water-resources/final-eastern-san-joaquin-groundwater-basin-groundwater-management-plan.pdf?Status=Master&sfvrsn=df184243_3. Accessed: May 16, 2024.

Northeastern San Joaquin County Groundwater Banking Authority. 2007. *Eastern San Joaquin Integrated Regional Water Management Plan.* July. Available: https://www.esjirwm.org/Portals/0/assets/docs/GBA-IRWMP.pdf. Accessed: May 16, 2024.

Northeastern San Joaquin County Groundwater Banking Authority. 2009. *Eastern San Joaquin Basin Integrated Conjunctive Use Draft Program Programmatic Environmental Impact Report.* September.

Northeastern San Joaquin County Groundwater Banking Authority. 2011. *Eastern San Joaquin Basin Integrated Conjunctive Use Program Programmatic Environmental Impact Report.* February.

Orange County. 2009. *Nitrogen and Selenium Management Program. Conceptual Model for Selenium–Newport Bay Watershed.* May.

Orange County Water District. 2014. *Long-Term Facilities Plan, 2014 Update.* November 19.

Orange County Water District. n.d. *Groundwater Replenishment System.*

Rancho California Water District, Riverside County Flood Control and Water Conservation District, County of Riverside, Stakeholder Advisory Committee. 2014. *Upper Santa Margarita Watershed, Integrated Regional Water Management Plan Update, Final.* April. Available: https://www.ranchowater.com/DocumentCenter/View/831/0-USMW-IRWM-Plan-Cover. Accessed: May 16, 2024.

Raymond Basin Management Board. 2014. *About Us.* Available: https://web.archive.org/web/20150908002919/http://raymondbasin.org/?page_id=25. Accessed: May 16, 2024.

Regional Water Authority. 2013. *American River Basin Integrated Regional Water Management Plan 2013 Update.* Available: https://rwah2o.org/programs/integrated-regional-water-management/american-river-basin-irwmp-2013-update/. Accessed: May 16, 2024.

Sacramento Central Groundwater Authority. 2010. *Basin Management Report 2009-2010.* Available: https://scgah2o.saccounty.gov/documents/2009-2010%20basin%20management%20report%20v2.pdf. Accessed: May 16, 2024.

Sacramento Groundwater Authority. 2013. *Basin Management Report Update 2013.*

Sacramento Groundwater Authority. 2014. *Groundwater Management Plan.* December. Available: https://www.sgah2o.org/wp-content/uploads/2016/06/GMP_SGA_2014_Final.pdf. Accessed: May 16, 2024.

San Diego County. 2010. *General Plan Update Groundwater Study.* April. Available: https://www.sandiegocounty.gov/content/dam/sdc/pds/gpupdate/docs/BOS_Aug2011/EIR/Appn_D_GW.pdf. Accessed: May 16, 2024.

San Diego County Water Authority, City of San Diego, and County of San Diego. 2013. *2013 San Diego Integrated Regional Water Management Plan, An Update of the 2007 IRWM Plan, Final.* September. Available: https://sdirwmp.org/2013-irwm-plan-update#codeword. Accessed: May 17, 2024.

San Diego Local Agency Formation Commission. 2011. *Directory of Special Districts in San Diego County.* Available: https://www.sdlafco.org/home/showpublisheddocument/3114/636916426871570000. Accessed: May 17, 2024.

San Joaquin County. 2009. *General Plan Update Background Report.* July.

San Joaquin County Flood Control and Water Conservation District. 2008. *Groundwater Report: Fall 1999–Spring 2007.* Available: http://www.sjwater.org/Portals/0/assets/docs/groundwater-reports/GroundH2O-Rprt-Fall99-Spring07.pdf?ver=2019-02-06-105825-670. Accessed: May 17, 2024.

San Juan Basin Authority. 2013. *San Juan Basin Groundwater and Facilities Management Plan.* November. Available: https://www.mwdoc.com/wp-content/uploads/2021/04/Appendix-E-San-Juan-Basin-Groundwater-and-Facilities-Management-Plan-reduced-size.pdf. Accessed: May 17, 2024.

San Luis Obispo County. 2011. *Groundwater Basin Management Plan.* March.

Santa Barbara County. 2007. *Santa Barbara Countywide Integrated Regional Water Management Plan.* May. Available: https://web.archive.org/web/20101119203425/http://www.countyofsb.org/pwd/pwwater.aspx?id=16866. Accessed: May 16, 2024.

Santa Clara Valley Water District. 2001. *Santa Clara Valley Water District Groundwater Management Plan.* July.

Santa Clara Valley Water District. 2010. *Revised Final Groundwater Vulnerability Study, Santa Clara County, California.* October. Available: https://www.valleywater.org/sites/default/files/2018-02/Groundwater%20Vulnerability%20Study.pdf. Accessed: May 16, 2024.

Santa Clara Valley Water District. 2012. *Annual Groundwater Report for Calendar Year 2012.* Available: https://californiarevealed.org/do/8ec34e66-64d7-4930-92c2-0ed4c139dff9. Accessed: May 17, 2024.

Santa Clara Valley Water District. 2016. *Groundwater Management Plan, Santa Clara and Llagas Subbasins.* November. Available: https://s3.us-west-2.amazonaws.com/assets.valleywater.org/2016%20Groundwater%20Management%20Plan.pdf. Accessed: May 17, 2024.

Santa Clara Valley Water District. 2017. *Annual Groundwater Report for Calendar Year 2017.* Available: https://www.valleywater.org/sites/default/files/2018-08/2017%20Annual%20GW%20Report_Web.pdf. Accessed: March 20, 2023

Santa Clara Valley Water District. 2018. *Annual Groundwater Report, for Calendar year 2017.* July.

Santa Margarita River Watershed Watermaster. 2011. *Santa Margarita River Watershed Annual Watermaster Report, Water Year 2009-10.* September. Available: https://www.wmwd.com/DocumentCenter/View/712/SMR-Annual-Report-2009-10?bidId=. Accessed: May 17, 2024.

Santa Maria Valley Management Area. 2012. *2011 Annual Report of Hydrogeologic Conditions, Water Requirements, Supplies, and Disposition.* April.

Solano County. 2008. *Solano County 2008 Draft General Plan, Final Environmental Impact Report.* July.

South Area Water Council. 2011. *South Basin Groundwater Management Plan. Working Draft.* April.

Stanislaus County. 2010. *Stanislaus County General Plan Support Documentation, Revised April 2010.* April. Available: https://web.archive.org/web/20101227095004/https://www.stancounty.com/planning/pl/general-plan.shtm. Accessed: May 17,2024.

Sutter County. 2012. *Groundwater Management Plan.* March. Available: https://www.suttercounty.org/home/showpublisheddocument/824/637474371331570000. Accessed: May 17, 2024.

Sweetwater Authority. 2016. *2015 Urban Water Management Plan.* June 27.

Tehama County Flood Control and Water Conservation District. 1996. *Coordinated AB 3030 Groundwater Management Plan.* November.

Tehama County Flood Control and Water Conservation District. 2008. *Tehama County AB-3030 Groundwater Management Plan. Background Document. Proposing Groundwater Trigger levels for Awareness Actions for Tehama County.* July. Available: https://ucanr.edu/sites/Tehama/files/20612.pdf. Accessed: May 17, 2024.

Twentynine Palms Water District. 2014. *Mission History.* Available: https://web.archive.org/web/20141001224500/http://www.29palmswater.net/mission-history.html. Accessed: May 17, 2024.

U.S. Fish and Wildlife Service. 2012. *Proposed Expansion San Joaquin River National Wildlife Refuge. Environmental Assessment, Land Protection Plan, and Conceptual Management Plan.* San Luis National Wildlife Refuge Complex Merced, Stanislaus, and San Joaquin Counties, CA.

U.S. Geological Survey. 1974. *Analog Model Study of the Ground-Water Basin of the Upper Coachella Valley, California.* Available: https://pubs.usgs.gov/wsp/2027/report.pdf. Accessed: May 17, 2024.

U.S. Geological Survey. 1986. *Geology of the Fresh Ground-Water Basin of the Central Valley, California, with Texture Maps and Sections: Regional Aquifer-System Analysis.* USGS Professional Paper 1401-C. U.S. Government Printing Office, Washington, D.C. Available: https://pubs.usgs.gov/publication/pp1401C. Accessed: May 17, 2024.

U.S. Geological Survey. 2006. *Sources of High-Chloride Water to Wells, Eastern San Joaquin Ground-Water Subbasin, California.* USGS Open File Report 2006-1309. Prepared in cooperation with Northeastern San Joaquin Groundwater Banking Authority and California Department of Water Resources. November. Available: https://pubs.usgs.gov/of/2006/1309/pdf/ofr2006-1309.pdf. Accessed: May 17, 2024.

U.S. Geological Survey. 2009. *Groundwater Availability of the Central Valley Aquifer, California.* U.S. Geological Survey Professional Paper 1766. Groundwater Resources Program.

U.S. Geological Survey. 2012. *Subsidence along the Delta-Mendota Canal.* Available: https://web.archive.org/web/20130504021754/http://ca.water.usgs.gov/projects/central-valley/delta-mendota-canal-subsidence.html. Accessed: May 17, 2024.

U.S. Geological Survey. 2013a. *Land Subsidence along the Delta-Mendota Canal in the Northern Part of the San Joaquin Valley, California, 2003-10. Scientific Investigations Report 2013-5142.* Available: https://pubs.usgs.gov/sir/2013/5142/pdf/sir2013-5142.pdf. Accessed: May 17, 2024.

U.S. Geological Survey. 2013b. A Geochemical Approach to Determine Sources and Movement of Saline Groundwater in a Coastal Aquifer. Published by National Ground Water Association. July. Available: https://ca.water.usgs.gov/pubs/2013/AndersEtAl2013.pdf. Accessed: May 17, 2024.

United Water Conservation District. 2012. *Groundwater and Surface Water Conditions Report – 2011, Open File Report 2012-02.* May. Available: https://www.unitedwater.org/wp-content/uploads/2020/10/GW_and_SW_Conditions_Report_-2011.pdf. Accessed: May 17, 2024.

Upper Los Angeles River Area Watermaster. 2013. *Annual Report, Upper Los Angeles River Area Watermaster, 2011-12 Water Year, October 1, 2011 – September 30, 2012.* May. Available: http://ularawatermaster.com/public_resources/WY_2011-12_ULARA_WM_Rpt_-5-2013.pdf. Accessed: May 17, 2024.

Upper San Gabriel Valley Municipal Water District. 2013. *Integrated Resources Plan.* January. Available: https://upperdistrict.org/wp-content/uploads/2020/03/IRP-Report-January-2013-Final-Approved-by-Board-2-5-13.pdf. Accessed: May 17, 2024.

Water Replenishment District of Southern California. 2007. *Battling Seawater Intrusion in the Central & West Coast Basins.* Technical Bulletin. Volume 13. Fall. Available: https://www.wrd.org/files/692a88b0a/TB13+-+Battling+Seawater+Intrusion+in+the+Central+%26+West+Coast+Basins.pdf. Accessed: May 17, 2024.

Water Replenishment District of Southern California. 2013a. *Engineering Survey and Report.* May 10.

Water Replenishment District of Southern California. 2013b. *Moving Towards 100% Recycled Water at the Seawater Intrusion Barrier Wells, Central Basin and West Coast Basin.* Volume 25. Spring. Available: https://www.wrd.org/files/954a1fa73/TB25+-+Moving+Towards+100%25+Recycled+Water+at+the+Seawater+Intrusion+Barrier+Wells+-+WRD+Service+Area.pdf. Accessed: May 17, 2024.

Water Resources Association of Yolo County. 2007. *Final Integrated Regional Water Management Plan.* April. Available: https://www.yologroundwater.org/files/e92f7438f/FINAL_IRWMP+Document_5-10-07.pdf. Accessed: May 17, 2024.

West Valley Water District. 2014a. *History of West Valley Water District.* Available: https://web.archive.org/web/20150909200348/https://www.wvwd.org/index.aspx?nid=92. Accessed: May 17, 2024.

West Valley Water District. 2014b. *Groundwater Wellhead Treatment System Project.* Available: https://web.archive.org/web/20141001065302/https://www.wvwd.org/index.aspx?NID=169. Accessed: May 17, 2024.

West Valley Water District. 2014c. *Baseline Feeder Water Supply Project.* Available: https://web.archive.org/web/20150923171843/http://www.wvwd.org/index.aspx?NID=197. Accessed: May 17, 2024.

Westlands Water District. 2018. Hydrologic Conceptualization Report, Westside Subbasin. Prepared for Westlands Water District. August 2. Prepared by: Luhdorff & Scalmanini Consulting Engineers. Available at https://sgma.water.ca.gov/portal/service/gspdocument/download/1977. Accessed October 24, 2024.

Yolo County. 2009. *Yolo County 2030 Countywide General Plan Environmental Impact Report.* April.

Yolo County Flood Control and Water Conservation District. 2012. *Regional Conjunctive Use Enhancement: Nitrate Fingerprinting and Groundwater Age Determination.* December.

Yuba County Water Agency. 2010. *Groundwater Management Plan.* December.

Yuima Municipal Water District. 2014a. *Yuima Municipal Water District, History.* Available: http://www.yuimamwd.com/content.php?ID=19. Accessed: July 11, 2014.

Yuima Municipal Water District. 2014b. *2013 Consumer Confidence Report.* June 1. Available: https://yuimamwd.com/images/web/images/file/Consumer%20Confidence%20Report/2013%20CCR%20Yuima%20Complete%20in%20COLOR.pdf. Accessed: May 17, 2024.

Yurok Tribe. 2012. *NPS Assessment and Management Program Plan.* December.

Zone 7 Water Agency. 2005. *Groundwater Management Plan for the Livermore-Amador Valley Groundwater Basin.* September. Available: https://www.zone7water.com/sites/main/files/file-attachments/gw-mgmt-plan_2005_0.pdf?1623862034. Accessed: May 17, 2024.

Zone 7 Water Agency. 2010. *Urban Water Management Plan.* December. Available: https://www.zone7water.com/sites/main/files/file-attachments/2010_uwmp-complete.pdf?1619986774. Accessed: May 17, 2024.

Zone 7 Water Agency. 2013. *Annual Report for the Groundwater Management Program 2012 Water Year Livermore Valley Groundwater Basin.* May.

Zone 7 Water Agency. 2018. *Groundwater Management Program Annual Report, Livermore Valley Groundwater Basin.* 2017 Water Year. March.