10. Groundwater Resources

10.1 Introduction

This chapter provides a description of the groundwater resources setting for the Primary, Secondary, and Extended study areas. Descriptions and maps of these three study areas are provided in Chapter 1 Introduction. Groundwater resources refer to the groundwater aquifer systems, including groundwater infrastructure (i.e., existing groundwater wells and their distribution facilities in the vicinity of the Sites Reservoir Project [Project]).

The regulatory setting for groundwater resources is presented in Appendix 4A Environmental Compliance.

This chapter focuses primarily on the Primary Study Area. Potential impacts in the Secondary and Extended study areas were evaluated and discussed qualitatively. Potential local and regional impacts from constructing, operating, and maintaining the alternatives were described and compared to applicable significance thresholds. Mitigation measures are provided for identified potentially significant impacts, where appropriate.

10.2 Environmental Setting/Affected Environment

Throughout the State, the availability and predictability of groundwater for withdrawal is influenced by the geology and topography of the region because groundwater may occur in alluvial sediment or fractured-rock aquifers. The characteristics of these aquifers are described in the following paragraphs.

Alluvial aquifers consist of unconsolidated materials (clay, silt, sand, or gravel) deposited by water. Alluvial aquifers are generally located in valley areas where the lower elevation of the ground surface has provided a location for eroded sediment to accumulate. Groundwater is collected and stored in the pore (void) spaces between the grains of the unconsolidated deposits. The volume of pore space available for groundwater storage and flow is a function of the physical characteristics of the formation such as grain size, grain shape, sorting (i.e., primarily one grain size or a mixture of many grain sizes), extent of lithification, and depth of burial. The groundwater production associated with alluvial sediment aquifers in California varies from very little to large quantities based on the composition of the sediment and availability of recharge to the aquifer system. In California, wells in alluvial sediment aquifers provide water for many uses including domestic, irrigation, industrial, environmental, and public water supply.

Fractured-rock aquifers in California are found primarily in mountainous regions where topography prevents the accumulation of significant amounts of eroded material. Groundwater collects and is stored in both the matrix (primary porosity) and fractures (secondary porosity) of the solid rock formations. Fractured-rock aquifers are generally considered to produce less groundwater and to be less predictable water sources than alluvial aquifers. Wells in fractured-rock aquifers provide water for many of the same uses as the wells in alluvial sediment aquifers but generally have lower yields and less reliable supply than wells completed in alluvial aquifers.

10.2.1 Extended Study Area

As described in Chapter 1, the Extended Study Area, consisting of the State Water Project (SWP) and Central Valley Project (CVP) service areas, is the largest and most diverse of the three study areas in terms of size, geography, land use, and habitat conditions, and includes the entire service areas of the SWP and CVP.

10.2.1.1 Hydrogeology and Groundwater Resources

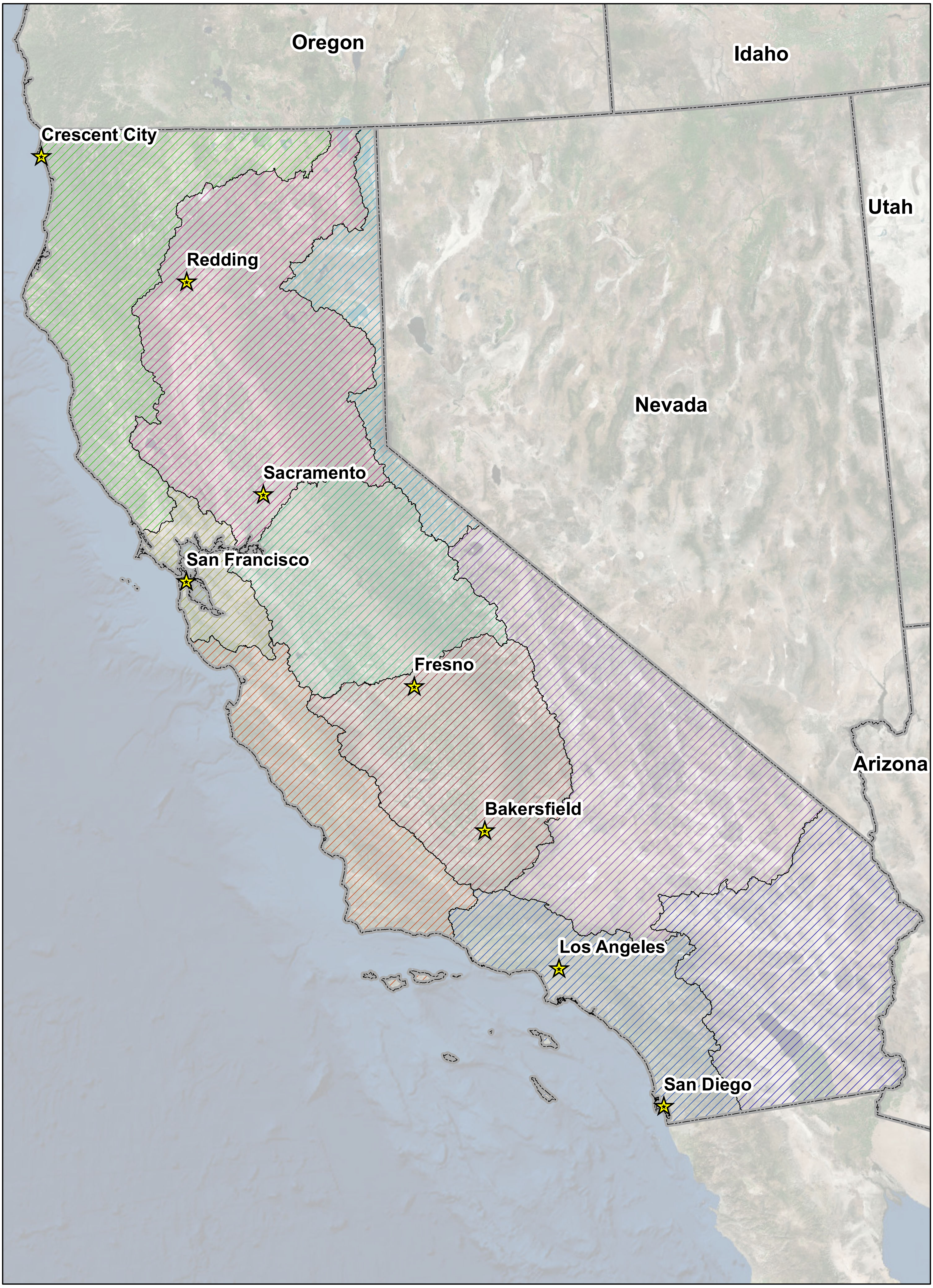
California is divided into 10 hydrologic regions based on surface water hydrology (Figure 10-1) (California Department of Water Resources [DWR], 2013). Brief descriptions of the groundwater hydrogeology and resources within the hydrologic regions where changes in water supply distribution may occur as a result of Project implementation are provided in the following paragraphs.

North Coast Hydrologic Region

The North Coast Hydrologic Region encompasses approximately 19,500 square miles in northwestern California (Figure 10-1) (DWR, 2013). The majority of the groundwater in the region is stored in alluvial aquifers, which have been categorized into 63 alluvial groundwater basins and subbasins (DWR, 2013) underlying approximately 8 percent of the hydrologic region. Fractured-rock aquifers in the foothill and mountain areas adjacent to the many alluvial groundwater basins also provide groundwater supply in the region. Groundwater reliability varies significantly from area to area. Localized fractured rocks within the Klamath, Butte, and Shasta Valley groundwater basins tend to form some of the most highly productive fractured-rock aquifers in California (DWR, 2013). Domestic wells make up the majority (71 percent) of documented wells in the well infrastructure in the region, monitoring wells account for 18 percent, irrigation wells account for approximately 5 percent, public water and industrial supply wells account for 3 percent, and other wells account for 4 percent. In the North Coast Hydrologic Region, there is limited large-scale groundwater development because of the small number of significant coastal aquifers. Groundwater development in this hydrologic region consists mainly of shallow wells installed adjacent to rivers. Groundwater is a significant water source for some small rural communities that rely on residential wells for water but overall contributes about one-third of the total water supply in the region. A majority (83 percent) of groundwater supplies are used for agricultural purposes while 16 percent is used to meet urban demand and approximately 1 percent is used to meet wetlands use.

San Francisco Bay Hydrologic Region

The San Francisco Bay Hydrologic Region (Bay Region) occupies approximately 4,500 square miles in west-central California (Figure 10-1) (DWR, 2013). The majority of the groundwater in the region is stored in alluvial aquifers that have been delineated into 33 alluvial groundwater basins and subbasins underlying approximately 31 percent of the hydrologic region (DWR, 2013). Fractured-rock aquifers in the foothill and mountain areas adjacent to the many alluvial groundwater basins also provide groundwater supply in the region. On average, wells drawing from fractured-rock aquifers yield 10 gallons per minute (gpm) or less in the Bay Region (DWR, 2013). Documented well infrastructure within the Bay Region consists of 66 percent monitoring wells, 15 percent “other” wells, 14 percent domestic wells, 4 percent irrigation wells, and <2 percent public and industrial supply wells. The majority of water demand in the Bay Region is met by imported surface water supplies, with groundwater comprising 21 percent of the total water supply in the region. The majority (71 percent) of groundwater supplies is used to meet urban demand while 29 percent is used for agricultural purposes.



Notes:
1. Hydrologic Region Boundary Source:
http://www.water.ca.gov/waterplan/gis/index.cfm
2. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

FIGURE 10-1
Hydrologic Regions of California
Sites Reservoir Project EIR/EIS

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Central Coast Hydrologic Region

The Central Coast Hydrologic Region occupies approximately 11,500 square miles in west-central California (Figure 10-1) (DWR, 2013). The majority of the water used in the Central Coast Hydrologic Region is derived from alluvial aquifers, which have been delineated into 60 alluvial groundwater basins and subbasins underlying approximately 35 percent of the hydrologic region (DWR, 2013). Fractured-rock aquifers in the foothill and mountain areas adjacent to the many alluvial groundwater basins also provide groundwater supply in the region. On average, wells drawing from fractured-rock aquifers yield 10 gpm or less in the Central Coast Hydrologic Region (DWR, 2013). Documented well infrastructure within the Central Coast Hydrologic Region consists of 55 percent domestic wells, 16 percent monitoring wells, 15 percent "other" wells, 12 percent irrigation wells, and less than 3 percent public and industrial supply wells. The Central Coast Hydrologic Region is the most groundwater-dependent hydrologic region in California, with approximately 85 percent of agricultural, municipal, and domestic water demands met by the extraction of groundwater. The majority (81 percent) of groundwater supplies is used for agricultural purposes, while 19 percent is used to meet urban demand.

South Coast Hydrologic Region

The South Coast Hydrologic Region occupies approximately 11,200 square miles in west-central California (Figure 10-1) (DWR, 2013). Groundwater is produced almost exclusively from alluvial aquifer systems, with groundwater production as high as thousands of gpm in large municipal wells (DWR, 2013). The alluvial aquifer systems in the South Coast Hydrologic Region have been delineated into 73 alluvial groundwater basins and subbasins underlying approximately 32 percent of the hydrologic region (DWR, 2013). Fractured-rock aquifers in the foothill and mountain areas adjacent to the many alluvial groundwater basins also provide groundwater supply in the region. On average, wells drawing from fractured-rock aquifers yield 10 gpm or less in the South Coast Hydrologic Region (DWR, 2013). Documented well infrastructure within the South Coast Hydrologic Region consists of 42.9 percent monitoring wells, 28 percent domestic wells, 14.7 percent "other" wells, 10.9 percent irrigation wells, and less than 3.5 percent public and industrial supply wells. The South Coast Hydrologic Region is the most populated hydrologic region in California. Approximately 34 percent of the region's water demand is met by the extraction of groundwater. The majority (76 percent) of groundwater supplies is used to meet urban demand, while 24 percent is used for agricultural purposes.

Sacramento River Hydrologic Region

The Sacramento River Hydrologic Region occupies approximately 27,200 square miles in north-central California (Figure 10-1) (DWR, 2013). The Sacramento Valley is considered to be one of the most productive aquifer systems in the state. Extensive deposition of alluvial material in the Sacramento Valley has created large, reliable, and productive aquifer systems. The alluvial aquifer systems in the Sacramento River Hydrologic Region have been delineated into 88 alluvial groundwater basins and subbasins underlying approximately 29 percent of the hydrologic region (DWR, 2013). Groundwater production and reliability are less predictable from the alluvial sediments in mountain basins, but many produce significant amounts of groundwater. Small scale production is achieved from fractured-rock aquifer systems outside of and along the edges of the alluvial basins (DWR, 2013). Documented well infrastructure within the Sacramento River Hydrologic Region consists of 72.2 percent domestic wells, 15.2 percent monitoring wells, 6.3 percent irrigation wells, 4.4 percent "other" wells, and 1.8 percent public and industrial supply wells. Approximately 30 percent of the region's water demand is met by the extraction of groundwater. Groundwater extraction in the Sacramento Hydrologic Region is the third highest among the 10 hydrologic regions in California (17 percent of all the groundwater extraction in California). The majority (84 percent) of groundwater supplies is used for agricultural purposes, while 16 percent is used to meet urban demand.

San Joaquin River Hydrologic Region

The San Joaquin River Hydrologic Region occupies approximately 15,300 square miles in the San Joaquin Valley of central California (Figure 10-1) (DWR, 2013). The majority of the water used in the San Joaquin River Hydrologic Region is derived from alluvial aquifers, which have been delineated into 11 alluvial groundwater basins and subbasins underlying approximately 38 percent of the hydrologic region (DWR, 2013). Pumping from the alluvial aquifers in the region accounts for about 19 percent of California's total average annual groundwater extraction (the second highest in the state) (DWR, 2013). Fractured-rock aquifers in the foothill and mountain areas adjacent to the many alluvial groundwater basins also provide groundwater supply in the region. On average, wells drawing from fractured-rock aquifers yield 10 gpm. There are notable exceptions, with deep wells (900 to 1,000 feet) producing yields of more than 100 gpm from fractured rock. Documented well infrastructure within the San Joaquin River Hydrologic Region consists of 65 percent domestic wells, 15 percent monitoring wells, 10 percent irrigation wells, 8 percent "other" wells, and less than 3 percent public and industrial supply wells. Approximately 40 percent of the region's water demand is met by the extraction of groundwater. The majority (81 percent) of groundwater supplies is used for agricultural purposes, 13 percent is used to meet urban demand, and 6 percent is used to meet managed wetlands requirements.

Tulare Lake Hydrologic Region

The Tulare Lake Hydrologic Region occupies approximately 16,800 square miles in the southern San Joaquin Valley of central California (Figure 10-1) (DWR, 2013). The majority of the water used in the Tulare Lake Hydrologic Region is derived from alluvial aquifers, which have been delineated into 12 groundwater basins and 7 subbasins underlying approximately 50 percent of the hydrologic region (DWR, 2013). Pumping from the alluvial aquifers in the region accounts for about 38 percent of California's total average annual groundwater extraction (the highest in the state) (DWR, 2013). The maximum thickness of freshwater aquifer deposits in the Tulare Lake Hydrologic Region is approximately 4,400 feet. Groundwater production in these areas generally ranges from 300 to 4,000 gpm. Aquifer deposits in the smaller basins surrounding the San Joaquin Valley are thinner and generally produce less groundwater, averaging less than 500 gpm (DWR, 2003). Fractured-rock aquifers in the foothill and mountain areas adjacent to the many alluvial groundwater basins also provide groundwater supply in the region (DWR, 2013). On average, wells drawing from fractured-rock aquifers yield 10 gpm. Documented well infrastructure within the Tulare Lake Hydrologic Region consists of 52 percent domestic wells, 24 percent irrigation wells, 15 percent "other" wells, 6 percent monitoring wells, and less than 4 percent public and industrial supply wells. Approximately 50 percent of the region's water demand is met by the extraction of groundwater. The majority (nearly 90 percent) of groundwater supplies is used for agricultural purposes, more than 9 percent is used to meet urban demand, and 0.5 percent is used to meet managed wetlands requirements.

North Lahontan Hydrologic Region

The North Lahontan Hydrologic Region occupies approximately 6,100 square miles in northwestern/west-central California (Figure 10-1) (DWR, 2013). Alluvial aquifers in the North Lahontan Hydrologic Region have been delineated into 27 groundwater basins and subbasins underlying approximately

26 percent of the hydrologic region (DWR, 2013). Groundwater production in the more heavily used alluvial basins ranges from less than 50 to 2,500 gpm (DWR, 2013). Fractured-rock aquifers in the foothill and mountain areas adjacent to the many alluvial groundwater basins also provide groundwater supply in the region. On average, wells drawing from fractured-rock aquifers yield 10 gpm; however, a significantly fractured bedrock aquifer in one of the groundwater basins is highly permeable and yields significant amounts of groundwater. Documented well infrastructure within the North Lahontan Hydrologic Region consists of 75 percent domestic wells, 8 percent irrigation wells, 5 percent "other" wells, 9 percent monitoring wells, and 3 percent public and industrial supply wells. Approximately 32 percent of the region's water demand is met by the extraction of groundwater. The majority (more than 70 percent) of groundwater supplies is used for agricultural purposes, 22 percent is used to meet urban demand, and 6 percent is used to meet managed wetlands requirements.

South Lahontan Hydrologic Region

The South Lahontan Hydrologic Region occupies approximately 26,800 square miles in west-central California (Figure 10-1) (DWR, 2013). The majority of the groundwater in the region is stored in alluvial aquifers, which have been delineated into 77 groundwater basins and 2 subbasins underlying approximately 55 percent of the hydrologic region (DWR, 2013). Groundwater development in the South Lahontan Hydrologic Region is limited to populated areas. Groundwater is produced almost exclusively from alluvial sediments and production varies greatly from basin to basin. Fractured-rock aquifers in the foothill and mountain areas adjacent to the many alluvial groundwater basins also provide groundwater supply in the region (DWR, 2013). On average, wells drawing from fractured-rock aquifers yield 10 gpm. Documented well infrastructure within the South Lahontan Hydrologic Region consists of 56 percent domestic wells, 4 percent irrigation wells, 11 percent "other" wells, 18 percent monitoring wells, 10 percent public supply wells, and 2 percent industrial supply wells. Approximately 67 percent of the region's water demand is met by the extraction of groundwater. The majority (61 percent) of groundwater supplies is used for agricultural purposes, while 39 percent is used to meet urban demand.

Colorado River Hydrologic Region

The Colorado River Hydrologic Region occupies approximately 20,000 square miles in southwest California (Figure 10-1) (DWR, 2013). The majority of the groundwater in the region is stored in alluvial aquifers, which have been delineated into 64 groundwater basins and subbasins underlying approximately 66 percent of the hydrologic region (DWR, 2013). Fractured-rock aquifers in the foothill and mountain areas adjacent to the many alluvial groundwater basins also provide groundwater supply in the region (DWR, 2013). On average, wells drawing from fractured-rock aquifers yield 10 gpm. Documented well infrastructure within the Colorado River Hydrologic Region consists of 61 percent domestic wells, 11 percent irrigation wells, 6 percent "other" wells, 17 percent monitoring wells, 4 percent public supply wells, and less than 1 percent industrial supply wells. Less than 10 percent of the region's water demand is met by the extraction of groundwater. The majority (87 percent) of groundwater supplies is used to meet urban demand, while 13 percent is used for agricultural purposes.

10.2.2 Secondary Study Area

The Secondary Study Area is smaller than and included with (that is, overlaps) the Extended Study Area and consists of the majority of SWP and CVP facilities that could be affected by Project operations. The Secondary Study Area consists of the geographical area with SWP and CVP facilities located north of the

Sacramento-San Joaquin Delta (Delta) and in the Delta, and the streams downstream of the SWP and CVP reservoirs could experience water surface elevation fluctuations or stream flow changes.

10.2.2.1 Hydrogeology and Groundwater Resources

The Secondary Study Area includes small portions of the North Coast and San Francisco Bay hydrologic regions and most of the Sacramento River Hydrologic Region. More detailed descriptions of the geologic setting and formations for the Secondary Study Area are included in Chapter 16 Geology, Minerals, Soils, and Paleontology.

North Coast Hydrologic Region

The portion of the North Coast Hydrologic Region that is included in the Secondary Study Area consists of areas surrounding Trinity Lake, Lewiston Lake, the Clear Creek Tunnel, the Trinity River, and the Klamath River downstream of the Trinity River north and northeast of Redding where the valley meets the base of the Klamath Mountain Range.

In general, the geologic setting for this area consists of ancient marine-type sedimentary rocks uplifted by massive granitic intrusions. Groundwater is produced from eroded and redeposited material that often collects along stream and river channels and in valley areas within the mountain region. Some groundwater is also produced from fractured hard rock aquifers. Groundwater production in the mountain region is less predictable and usually less productive than in most parts of the valley because the geologic material storing the groundwater is much more limited.

San Francisco Bay Hydrologic Region

The portion of the Bay Region that is included in the Secondary Study Area consists of areas surrounding the Delta, Suisun Bay, San Pablo Bay, and San Francisco Bay.

In general, the geologic setting for these areas consists of alluvial deposits of material eroded from rocks higher in the watersheds that were transported and deposited by rivers and streams feeding into the Region. Groundwater is produced from these alluvial sediments. Groundwater production varies from area to area because coarse sediments that store groundwater vary in thickness.

Sacramento River Hydrologic Region

The portions of the Sacramento River Hydrologic Region included in the Secondary Study Area is the Sacramento Valley, which includes both the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. The Sacramento Valley is bordered by the Klamath Mountains and Cascade Ranges on the north, the Coast Ranges to the west, and the Sierra Nevada to the east. The valley is approximately 25 miles wide near the City of Red Bluff and approximately 50 miles wide south of the Sutter Buttes. The length of the Sacramento Valley is roughly 180 miles. Major surface water features included in the Sacramento River Hydrologic Region are Shasta Lake, Keswick Reservoir, the Sacramento River, Spring Creek, Clear Creek, Whiskeytown Lake, Lake Oroville, the Thermalito Complex, the Feather River, Sutter Bypass, Yolo Bypass, Folsom Lake, Lake Natoma, and the American River.

The Redding Groundwater Basin covers approximately 510 square miles in parts of Shasta and Tehama counties and comprises the northernmost portion of the Sacramento Valley. The Basin is bordered by the Klamath Mountains to the north, the Coast Range to the west, and the Cascade Mountains to the east. The Red Bluff Arch, between Cottonwood and Red Bluff, separates the Redding Groundwater Basin from the Sacramento Valley Groundwater Basin to the south. The Redding Groundwater Basin consists of a sediment-filled, southward-plunging symmetrical trough (DWR, 2003). Simultaneous deposition of material from the Coast Range and the Cascade Range resulted in two different formations, which are the principal freshwater-bearing formations in the basin (the Tehama and Tuscan formations, respectively). The base of freshwater in the basin coincides with the top of the Chico Formation, which is composed of marine deposits of sandstone, conglomerates, and shale, and contains salt water under artesian pressure. The Tuscan and Tehama Formations are at most 2,000 feet thick near the confluence of the Sacramento River and Cottonwood Creek (Pierce, 1983). The Tuscan and Tehama formations are generally overlain by the moderately permeable Red Bluff Formation. A description of these lithologic units is provided in Table 10-1.

Table 10-1
Major Lithologic Units of the Sacramento Valley

Geologic Unit	Geologic Age	Description	Water-bearing Properties
Alluvium	Quaternary (Holocene)	Alluvial deposits not included as fans or flood basin deposits are found throughout the Sacramento Valley and consist of stream channel, natural levee, and floodplain deposits. Alluvium consists primarily of sands and gravel with minor amounts of silt and clay. Large, coarse-grained deposits are associated with larger streams in the Valley.	Stream channel deposits have high yields.
Flood Basin Deposits	Quaternary (Holocene)	Flood basin deposits are found in five distinct basins along the Sacramento River. During flood conditions, silts, clays, and fine sands were deposited in low-lying areas between the natural levees of streams and the alluvial plains on the Valley sides.	Insufficient data, but yields expected to be low given the fine-grained nature of the deposits.
Alluvial Fan Deposits	Quaternary (Pleistocene-Holocene)	Alluvial fan deposits are found along the western side of the Sacramento Valley from Stony Creek southward. Alluvial fans along the eastern side of the Valley are limited to the Chico area. Coalescing fans comprise materials ranging from clay to gravel. Alluvial fans in the Stony Creek and Chico areas contain a high proportion of coarse-grained materials.	Coarse-grained alluvial fans (Stony Creek) have reported yields up to 4,000 gpm. Alluvial fans dominated by finer-grained materials have lower yields.
Modesto Formation	Quaternary (Pleistocene)	Terrace deposits consisting of moderately to highly permeable gravels, sands, and silts. Thickness of the formation ranges from less than 10 feet to nearly 200 feet across the valley floor.	The formation yields moderate quantities of water to domestic and shallow irrigation wells and also provides water to deeper irrigation wells that have multiple zones of perforation.
Riverbank Formation	Quaternary (Pleistocene)	Older terrace deposits that occur at a higher topographic level and consist of poorly to highly pervious pebble and small cobble gravels interlensed with reddish clay, sand, and silt. Thickness of the formation ranges from less than 1 foot to over 200 feet depending on location.	The formation yields moderate quantities of water to domestic and shallow irrigation wells and also provides water to deeper irrigation wells that have multiple zones of perforation.

Geologic Unit	Geologic Age	Description	Water-bearing Properties
Victor Formation	Quaternary (Pleistocene)	The Victor Formation is present on the eastern side of the Sacramento Valley where it forms a broad plain. The unit was deposited on a plain of aggradation by shifting streams draining the Sierra Nevada. The Victor Formation consists of stream channel sand and gravel deposits that grade laterally and vertically to silts and clays with a thickness up to 100 feet.	Important water-bearing unit for domestic and shallow irrigation wells. Limited data are available for wells completed entirely in the Victor Formation; yields up to 1,900 gpm are estimated for channel deposits of sand and gravel.
Arroyo Seco Gravel South Fork Gravels Red Bluff Formation	Quaternary (Pleistocene)	Small gravel deposits that form caps to the low hills and dissected uplands along the eastern and western sides of the Sacramento Valley. Gravel deposits are associated with glaciation of the Sierra Nevada and Coast Ranges and are generally either cemented or contain hardpan soils.	Not important water-bearing units, generally found above the regional water table, where units are saturated; well yields are generally low.
Fanglomerate	Quaternary (Pleistocene)	This unnamed geologic unit is restricted to the northeastern portion of the Sacramento Valley (north of Chico). The unit consists of coalescing alluvial fans derived from erosion of outcrops of the Tuscan Formation. The fanglomerates consist predominantly of cemented sand and gravel with large amounts of clay.	Estimated to have low to moderate yields.
Laguna Formation Fair Oaks Formation	Tertiary-Quaternary (Pliocene to middle-Pleistocene)	The Laguna Formation outcrops along the eastern margin of the basin and consists of westward-thickening deposits of silt, clay, and sand with gravel lenses. The Laguna Formation was deposited by streams draining the Sierra Nevada, with primarily granitic and metamorphic mineralogy (little/no volcanics). In portions of Sacramento County, deposits are referred to as the Fair Oaks Formation.	Finer-grained portions of the formation have low well yields. Well sorted sand units have reported well yields up to 1,750 gpm.
Tehama Formation	Tertiary-Quaternary (Pliocene to middle-Pleistocene)	The Tehama Formation occupies entire western portion of the Sacramento Valley and consists of predominantly fine-grained materials (silts and clays) with thin/discontinuous lenses of sand and gravel derived from erosion of the Coast Ranges and the Klamath Mountains. The relative proportion of coarse-grained materials varies spatially within the unit. The Tehama Formation extends eastward from the Valley margin and interfingers with the Tuscan and Laguna Formations at depth beneath the central portion of the Valley. The average thickness of the unit beneath the western half of the Sacramento Valley is approximately 2,000 feet.	The Tehama Formation is a principal water-bearing unit in the Sacramento Valley with reported well yields up to 4,000 gpm.
Mehrten Formation	Tertiary (Pliocene)	The Mehrten Formation is a volcanic unit that outcrops primarily along the southeastern margin of the Sacramento Valley. The formation is divided into two units: an upper fluvatile unit of interbedded black sands and blue to brown clay and a lower unit consisting of dense tuff-breccia. The formation dips and thick kens to the southwest.	The black sands of the Valley Springs Formation yield large quantities of fresh water to wells.

Geologic Unit	Geologic Age	Description	Water-bearing Properties
Tuscan Formation	Tertiary (Pliocene)	The Tuscan Formation outcrops in the east/northeastern portion of the Sacramento Valley and dips westward. The formation underlies approximately 900 square miles of the Valley. The Tuscan Formation is a wedge-shaped unit that thins from approximately 1,000 to 1,600 feet in the eastern outcrop areas to approximately 300 feet beneath the Valley center where it interfingers with the Tehama Formation. The unit consists of stream-deposited black volcanic sands, tuffaceous clay, and gravel.	The Tuscan Formation is an important water bearing unit in the Sacramento Valley, with reported well yields up to 3,000 gpm.
Valley Springs Formation	Tertiary (Miocene)	The Valley Springs Formation outcrops primarily along the southeastern margin of the Sacramento Valley. The unit consists of southwestward-dipping sequence of rhyolitic ash, clay, sand, and gravel deposited by streams with thickness up to approximately 200 feet.	Fresh water-bearing unit; low yields because of the presence of fine-grained materials.
Marine and Continental Deposits (Includes Ione Formation)	Tertiary (Eocene)	Mixed marine and continental sediments deposited in a semi-isolated basin during and following uplift of the Coast Range. With transgression and regression of seas, some deposits contain both marine and sedimentary materials. Ione formation was deposited in a marsh-like environment in the east/southeastern portion of the Sacramento Valley and in fluvatile to marine environments in other portions of the Central Valley. The unit outcrops along the eastern margin of the Sacramento Valley and dips southwestward. The Ione Formation consists of clay, sand, sandstone, and conglomerate up to 400 feet thick.	Largely non-water bearing or saline. Where deposited in near-shore environment, the Ione Formation yields small quantities of fresh water to wells (up to 50 gpm).
Volcanics (Includes Sutter Buttes)	Tertiary	Andesitic and rhyolitic volcanics within interior of the Sacramento Valley.	Primarily non-water-bearing.
Marine Rocks (Includes Chico Formation)	Cretaceous	Outcrop primarily along the western side of the Sacramento Valley. Sedimentary rocks consisting primarily of eastward-dipping (and thickening) sandstones and shales.	Generally contain connate water or yield small volumes.
Basement Rocks	Pre-Tertiary	Igneous and metamorphic rocks that underlie the sedimentary deposits. Outcrops are limited to the eastern portion of the Valley, in the Sierra Nevada, and slope southwest. Igneous rocks include granitics with some mafic intrusions. Metamorphic rocks include metasedimentary, metavolcanic, and undifferentiated metamorphics.	Primarily impermeable boundary at base of groundwater basin; fractures and joints yield small quantities of water.

Notes:

Lithologic descriptions from DWR (1978), DWR (2003), and Page (1986)

The Sacramento Valley Groundwater Basin is a north-northwestern trending asymmetrical trough filled with as much as 10 miles of both marine and continental rocks and sediment (Page, 1986). On the eastern side, the basin overlies basement bedrock that rises relatively gently to form the Sierra Nevada. On the western side, the underlying basement bedrock rises more steeply to form the Coast Ranges. Marine sandstone, shale, and conglomerate rocks that generally contain brackish or saline water overlie the basement bedrock. The more recent continental deposits overlying the marine sediments contain fresh water. These continental deposits are generally 2,000 to 3,000 feet thick (Page, 1986). The depth (below ground surface [bgs]) to the base of fresh water typically ranges from 1,000 to 3,000 feet (Berkstresser, 1973). Three areas of bedrock outcrop are present within the interior of the Sacramento Valley. These include the Sutter Buttes, Black Butte, and the Dunnigan Hills. Along the edges of the basin, near the base of the mountains, groundwater is produced from limited fractured-rock aquifers. In areas outside of the Sacramento Valley, groundwater occurs in alluvium deposited in smaller valleys and along stream and river channels. Groundwater is also produced from fractured-rock areas and in the Cascade Range from sand and gravel aquifers found between ancient lava flows. Descriptions of the lithologic units within the Sacramento Valley Groundwater Basin are listed in Table 10-1 (Page, 1986; DWR, 1978; DWR, 2003).

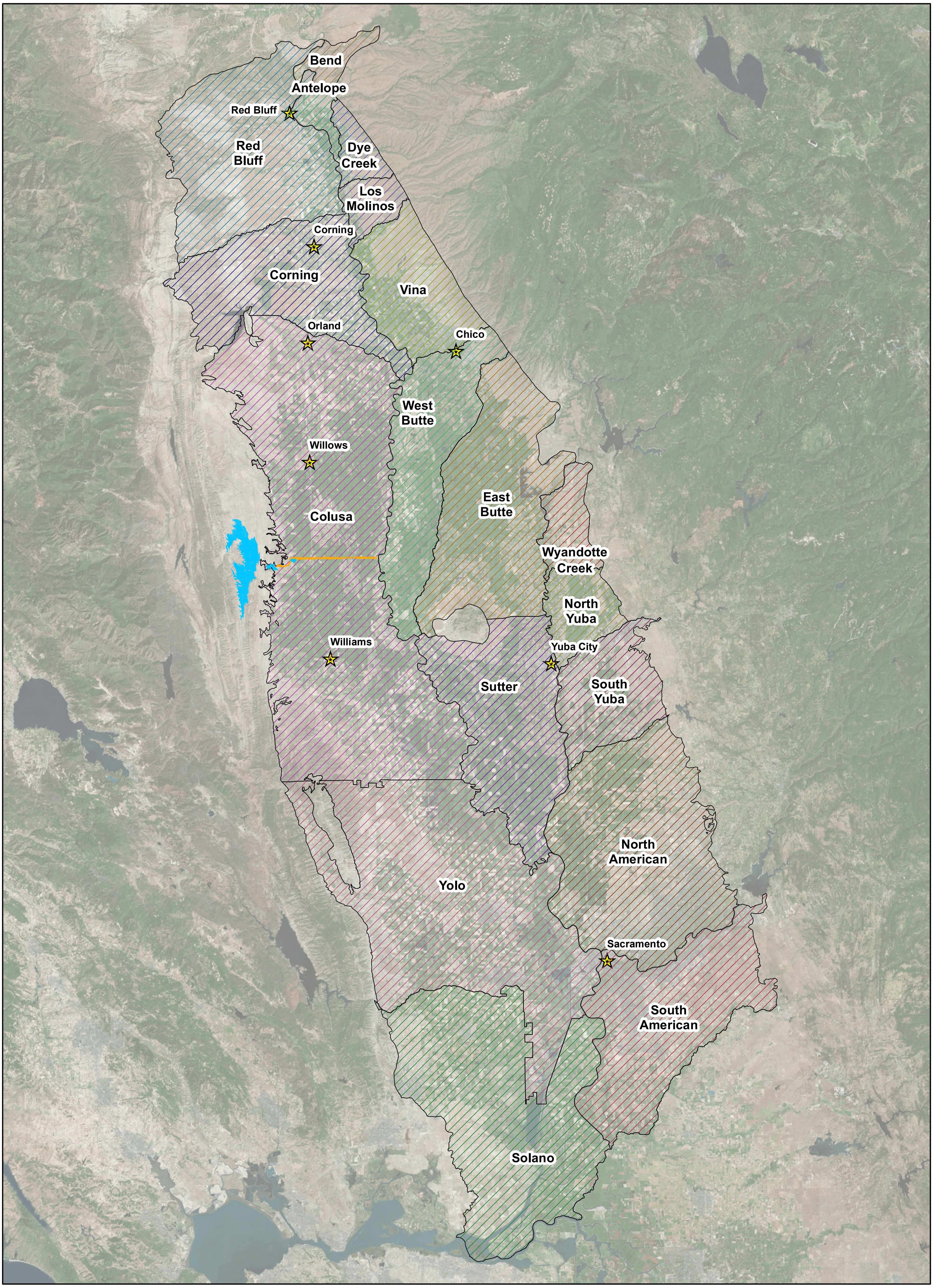
10.2.3 Primary Study Area

The Primary Study Area consists of the geographical areas that could be directly affected by the construction and operations of the Project facilities, and the land immediately surrounding them that would be included in the Project boundary (referred to in this document as the Project Buffer); as such, this study area is the primary focus of the resource evaluations in this Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS). The Primary Study Area includes the “footprints” of the proposed Sites Reservoir proposed facilities (e.g., dams, intakes/discharge facilities, fish screens, pipelines, overhead power line, pumping/generating plants, recreation areas, road relocation areas, borrow areas, and associated facilities) other than the Tehama-Colusa Canal Authority (TCCA) and Glenn-Colusa Irrigation District (GCID) diversion facilities. The Primary Study Area is located within Glenn and Colusa counties.

10.2.3.1 Hydrogeology and Groundwater Resources

With the exception of the Sites Reservoir Complex, the majority of the Primary Study Area is located within the Colusa Subbasin (5-021.52) of the Sacramento Valley Groundwater Basin. Detailed discussions of the geology and hydrogeology of the northern Sacramento Valley Groundwater Basin (which includes the Colusa Subbasin) including geologic maps, stratigraphic sections, and geologic cross sections can be found in DWR (1978), DWR (2003), DWR (2014), and DWR (2016). Figure 10-2 presents the distribution of Groundwater Subbasins in Sacramento Valley Groundwater Basin. The extent of the Colusa Subbasin is defined by the Sacramento River to the east, Stony Creek to the north, the Coast Range and foothills to the west, and the Colusa/Yolo County Line to the south. Hydrostratigraphic units containing fresh water within the Colusa Subbasin include, from oldest to youngest, the Tuscan Formation (derived from the Sierra Nevada), the Tehama Formation (derived from the Coast Ranges), the Modesto Formation, ~~and~~ the Riverbank Formation, alluvial fan, basin deposits, and stream deposits (Table 10-1). A generalized geologic map is provided in Chapter 16, Figure 16-2.

Groundwater within the Colusa Subbasin generally flows from the recharge areas along the basin margin in the west to the east/southeast toward the Sacramento River. There are localized areas of groundwater flow to the west/southwest in the northern portion of the subbasin (Stony Creek Fan). Figures 10-3 and 10-4 present groundwater elevation contours as inferred from groundwater level data collected in spring 2016 and fall 2015, respectively. Recent depth to groundwater was generally less than 10 to 20 feet bgs across much of the subbasin during spring 2016, and generally 20 to 40 feet bgs during fall 2015 (DWR, 2017a). Greater depths to groundwater (up to 200 feet bgs) are found along the northwestern and southwestern basin margins. Groundwater levels, particularly in these areas, have declined over the last decade. Comparison of spring 2004 and 2014 groundwater elevations shows a decline of 40 to 50 feet along the northwestern and southwestern basin margins (Figure 10-5). This decline in groundwater levels



LEGEND

Groundwater Subbasin

- Antelope
- Bend
- Colusa
- Corning
- Dye Creek
- East Butte
- Los Molinos
- North American
- North Yuba
- Red Bluff
- Solano
- South American
- South Yuba
- Sutter
- Vina
- West Butte
- Wyandotte Creek
- Yolo

Select Project Features (Locations Approximate)

- Pipeline Construction Disturbance Area
- Reservoir

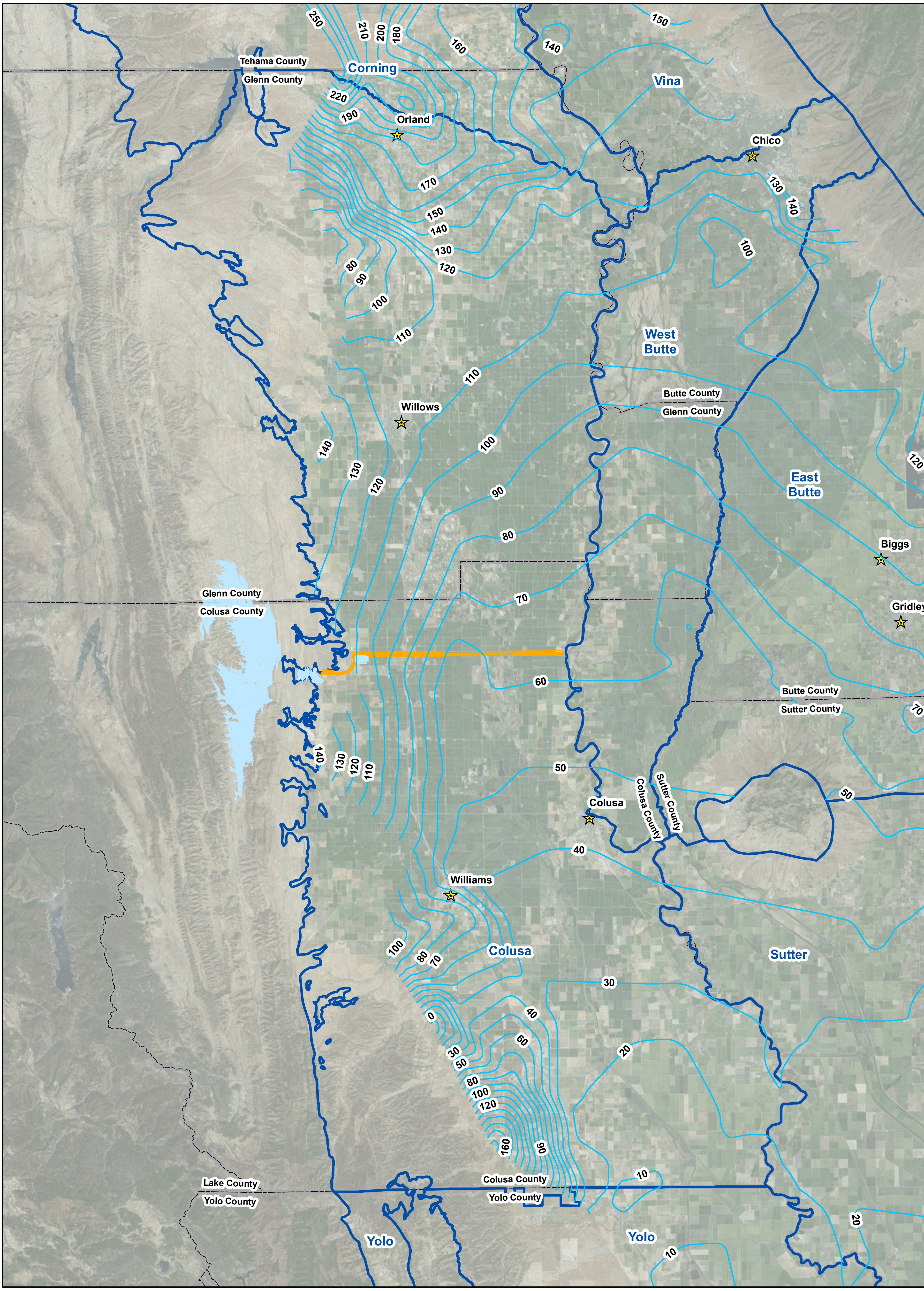
Notes:
1. Groundwater Subbasin Boundary and Elevation Source: https://gis.water.ca.gov/app/gicima/
2. NAVD88 = North American Vertical Datum of 1988
3. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

N

0 3 6 12
Miles

FIGURE 10-2
Subbasins of the Sacramento Valley Groundwater Basin
Sites Reservoir Project EIR/EIS

RDD \\ODIN\PROJ\SITESJPA\668147NODOS\HYDROGEOLOGY\FIGURES\FIGURE_10-02_GW_SUBBASINS.MXD ED035443 3/9/2017 11:22:12 AM



LEGEND

Groundwater Elevation Contour (feet NAVD88)

Groundwater Subbasin Boundary

County Boundary

Select Project Features (Locations Approximate)

Pipeline Construction Disturbance Area

Reservoir

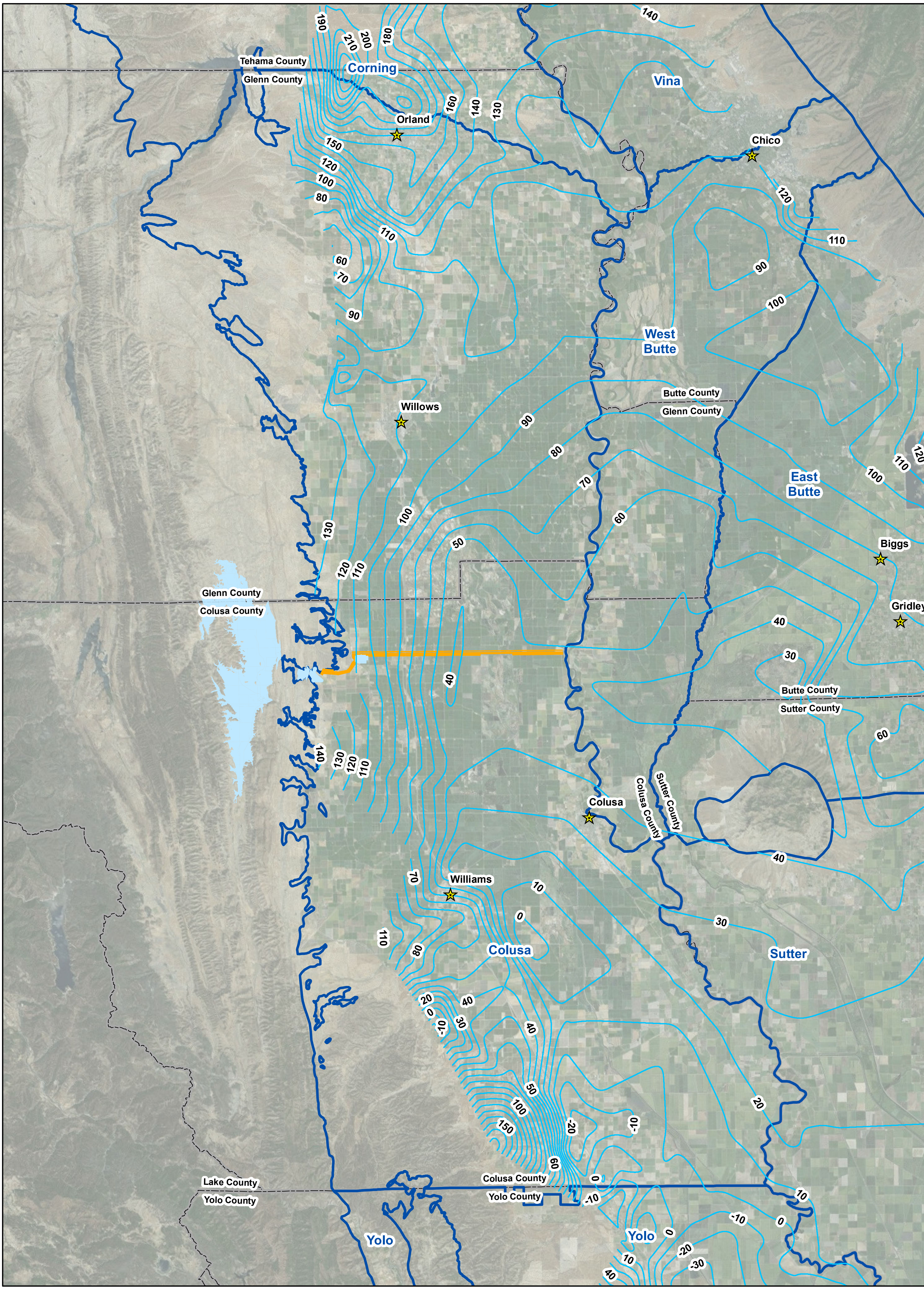
0 2.5 5 10

Miles

N

Notes:
1. Groundwater Subbasin Boundary and Elevation Source: https://gis.water.ca.gov/app/gicima/
2. NAVD88 = North American Vertical Datum of 1988
3. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 10-3
Spring 2016 Groundwater Elevation Contour Map
Sites Reservoir Project EIR/EIS



LEGEND

Groundwater Elevation Contour (feet NAVD88)

Groundwater Subbasin Boundary

County Boundary

Select Project Features (Locations Approximate)

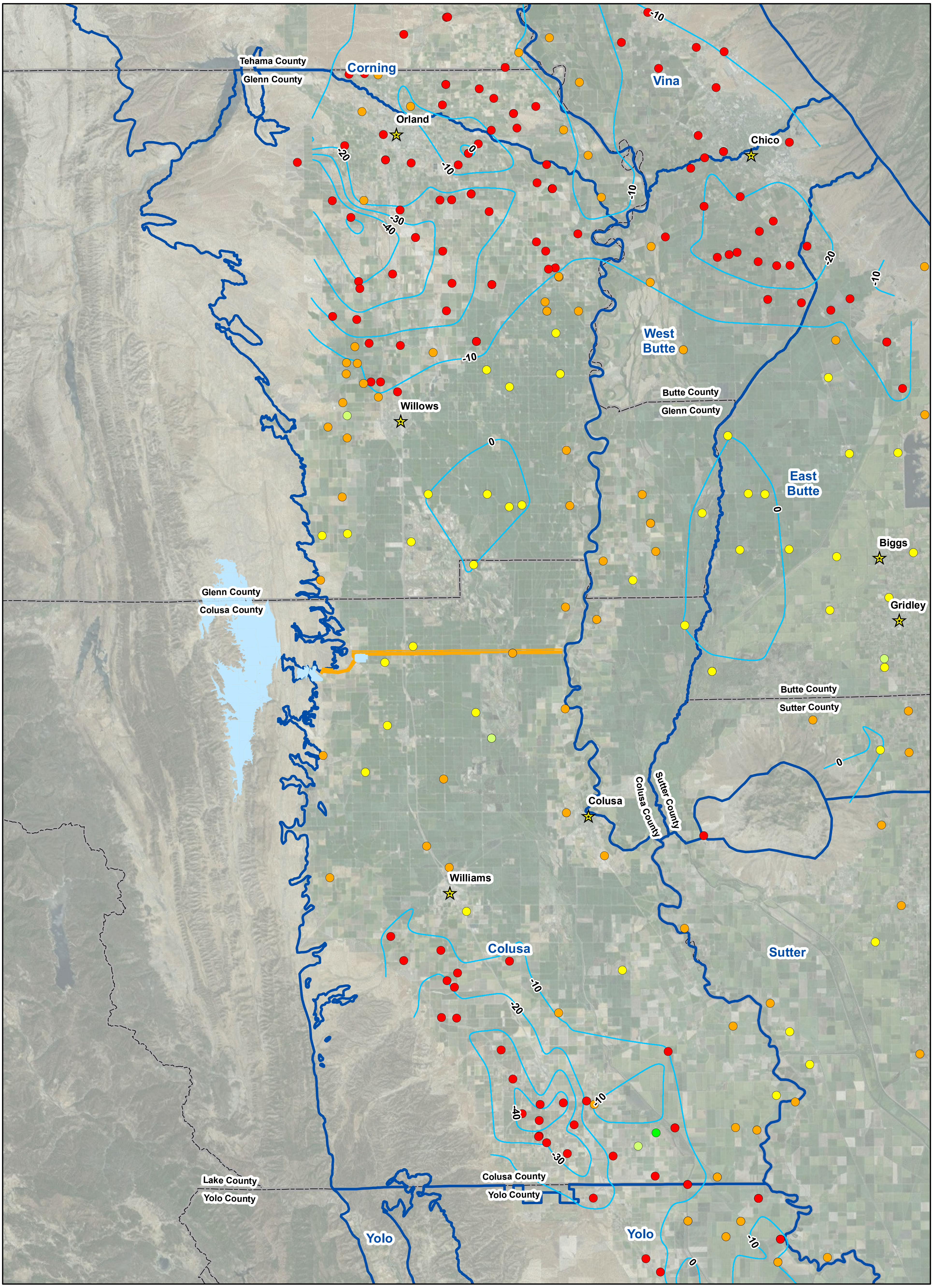
Pipeline Construction Disturbance Area

Reservoir

0 2.5 5 10 Miles

Notes:
1. Groundwater Subbasin Boundary and Elevation Source: https://gis.water.ca.gov/app/gicima/
2. NAVD88 = North American Vertical Datum of 1988
3. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 10-4
Fall 2015 Groundwater Elevation Contour Map
Sites Reservoir Project EIR/EIS



LEGEND

- Change in Groundwater Level (feet)
- Groundwater Subbasin Boundary
- County Boundary

Select Project Features (Locations Approximate)

- Pipeline Construction Disturbance Aea
- Reservoir

Change in Groundwater Level (feet)

- Decrease >10
- Decrease 2.5 to 10
- +/- 2.5
- Increase 2.5 to 10
- Increase >10

0 2.5 5 10
Miles

Notes:
1. Groundwater Subbasin Boundary and Elevation Source: https://gis.water.ca.gov/app/gicima/
2. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 10-5
Change in Groundwater Elevation
Spring 2004 to Spring 2014
Sites Reservoir Project EIR/EIS

is likely related to a combination of recent multi-year drought conditions (decreasing groundwater recharge) and an increase in permanent, groundwater-supplied agricultural areas (increasing groundwater extraction) (Davids Engineering, 2016). Groundwater and surface water are hydraulically connected within the Sacramento Valley Groundwater Basin, with generally losing conditions along tributary streams at the basin margin, transitioning to gaining conditions along the major trunk streams draining the valley. However, local conditions may vary depending primarily on groundwater use in particular areas.

Sites Reservoir Inundation Area, Dams, Recreation Areas, Roads and South Bridge, Sites Reservoir Inlet/Outlet Structure, Sites Pumping/Generating Plant, Tunnel from Sites Pumping/Generating Plant to Site Reservoir Inlet/Outlet Structure, and Sites Electrical Switchyard

Local Hydrogeology

The proposed location for the Sites Reservoir Inundation Area would completely inundate both the Funks and Antelope Creek groundwater basins. These groundwater basins consist primarily of shallow (generally less than 100 feet) alluvial deposits (DWR, 2003). These alluvial deposits are Late Quaternary (8,000 years ago) in age and occur within the reservoir footprint, primarily along the valleys of Stone Corral, Antelope, Funks, and Grapevine creeks. The deposits consist of fine-grained sands, silts, and clays occurring as stream channel and localized floodplain deposits.

Most of the wells in these groundwater basins are designed to produce water from the underlying rock formation (the Great Valley Sequence). The Great Valley Sequence consists of marine, clastic sedimentary rock consisting of siltstone, shale, sandstone, and conglomerate. The sequence has a maximum thickness of 15,000 feet. Groundwater resources from this formation are limited because of poor water-bearing and water quality characteristics. More detailed descriptions of the geologic setting and formations are included in Chapter 16 Geology, Minerals, Soils, and Paleontology.

Local Groundwater Infrastructure

There are approximately 30 wells and 1 test hole that have been constructed within an approximate 1-mile radius of the Sites Reservoir footprint (Senter, 2017, pers. comm.). Table 10-2 presents a summary of data for these wells, including the number of wells, well depth, well use, depth to water, and well yield, for the appropriate Township, Range, and Section. The data presented here are from the DWR well completion report data set. Data are reported as it was submitted by the well driller at the time of drilling and development. These data were verified by DWR staff and conditions may have changed since the time of drilling. Additional wells may be present in the study area that were not reported to DWR by the driller.

As shown in Table 10-2, 13 wells are constructed to a depth of 100 feet or greater, the deepest well being 201 feet deep. Well yields in the area are low, ranging from a high of 60 gpm to a low of zero or no measurable yield, and averaging approximately 14 gpm. The depth to water in the area, based on well completion reports, ranges from 1 foot to 30 feet bgs, with an average depth of approximately 17 feet (DWR, 2011; Senter, 2017, pers. comm.).

Table 10-3 provides a summary of well data for each type of well (e.g., domestic or irrigation), as reported on well completion reports submitted to DWR. As shown, half of the wells in the area are domestic wells constructed to depths ranging from approximately 30 to 165 feet, with yields averaging approximately 14 gpm. Stock wells are the second most common well type in the area, constructed to depths ranging from 20 to 200 feet. Well yields from stock wells average approximately 15 gpm.

Table 10-2
Wells Located within a 1-mile Radius of the Proposed Sites Reservoir Footprint[a]

Township, Range, and Section Number	Number of Wells within Section	Well Depth (feet)	Well Use	Depth to Water (feet)[b]	Well Yield (gpm)[b]
T16N R04W Sec 06	1	201	Stock	20	20
T16N R04W Sec 18	1	60	Test Well	NA	NA
T16N R04W Sec 19	2	119	Domestic	21	15
		31	Domestic	16	15
T16N R05W Sec 12	2	85	Irrigation	NA	NA
		75	Stock	NA	0
T16N R05W Sec 23	1	86	Stock	4	8
T16N R05W Sec 24	1	140	Domestic	12	7
T17N R04W Sec 06	1	20	Stock	10	60
T17N R04W Sec 08	1	105	Stock	7	NA
T17N R04W Sec 16	1	124	Domestic	17	12
T17N R04W Sec 19	1	29	Stock	18	2
T17N R04W Sec 20	10	84	Domestic	10	10
		37	Domestic	18	5
		47	Domestic	NA	NA
		45	Domestic	26	NA
		28	Domestic	NA	NA
		48	Domestic	NA	NA
		200	Industrial	30	3
		100	Industrial	17	20
		70	Domestic	30	50
		160	Domestic	22	25
T17N R04W Sec 31	1	60	Stock	20	10
T17N R05W Sec 02	1	60	Stock	NA	10
T17N R05W Sec 04	1	164	Domestic	NA	3
T17N R05W Sec 24	1	80	Domestic	30	5
T18N R04W Sec 07	1	140	Irrigation	NA	8
T18N R04W Sec 17	1	140	Irrigation	NA	5
T18N R05W Sec 13	1	100	Domestic	10	10
T18N R05W Sec 14	1	100	Stock	10	10
T18N R05W Sec 25	1	38	Domestic	1	NA

[a]The number of wells within a 1-mile radius of the project feature were determined based on the Township/Range/Sections falling within 1 mile of the project feature.

[b]Depth to water and well yield values are based on estimates provided by the driller at the time of drilling in well completion reports.

Note:

NA = Not Available

Sources: DWR, 2011; DWR, 2017a.

Table 10-3
Summary of Well Data by Well Type for Wells Located within a 1-mile Radius of the Sites Reservoir Footprint[a]

Well Type	Number of Wells	Average Well Depth (feet)	Average Depth of Water (feet)[b]	Average Well Yield (gpm)[b]
Domestic	16	82	17.8	14.3
Irrigation	3	121	NA	6.5
Industrial	2	150	23.5	11.5
Stock	9	82	12.7	15
Other	1	60	NA	NA

[a]The number of wells within a 1-mile radius of the project feature were determined based on the Township/Range/Sections falling within 1 mile of the project feature.

[b]Depth to water and well yield values are based on estimates provided by the driller at the time of drilling in well completion reports.

Sources: DWR, 2011; Senter, 2017, pers. comm.

Holthouse Reservoir Complex, Tehama-Colusa Canal, Field Office Maintenance Yard, Terminal Regulating Reservoir Pipeline, and Terminal Regulating Reservoir Pipeline Road

Local Hydrogeology

The Holthouse Reservoir Complex (proposed location), Tehama-Colusa Canal (proposed modifications), and the Field Office Maintenance Yard, Terminal Regulating Reservoir (TRR) Pipeline, and TRR Pipeline Road would overlie Great Valley Sequence and Holocene basin deposits. The Great Valley Sequence consists of marine clastic sedimentary rock consisting of siltstone, shale, sandstone, and conglomerate. The sequence has a maximum thickness of 15,000 feet. Groundwater resources in this area are limited because of the poor water-bearing and water quality characteristics.

The basin deposits consist of silt and clay deposited in low-lying floodplain areas adjacent to major streams. Permeability of basin deposits is generally low and groundwater occurs in limited quantities.

Local Groundwater Infrastructure

There are approximately 15 wells that have been constructed and two test holes drilled within an approximate 1-mile radius of the proposed Holthouse Reservoir Complex (DWR, 2011; Senter, 2017, pers. comm.). Table 10-4 presents a summary of well data for these wells including the number of wells, well depth, well use, depth to water, and well yield, for the appropriate township, range, and section. The data presented here are from the DWR well completion report data set. Data are reported as it was submitted by the well driller at the time of drilling and development. None of this data was verified by DWR staff and conditions may have changed since the time of drilling. Additional wells may be present in the study area that were not reported to DWR by the driller.

The constructed well depths ranged from 70 feet to 400 feet and the reported well yields ranged from 11 to 200 gpm. Depth to water measurements reported on the well completion reports ranged from 15 to 41 feet bgs. A majority of wells near the proposed Holthouse Reservoir Complex (61 percent) are used for domestic supply.

Table 10-4
Wells Located within a 1-mile Radius of the Proposed Holthouse Reservoir Complex and Terminal Regulating Reservoir Pipeline[a]

Section Number	Number of Wells within Section	Well Depth (feet)	Well Use	Depth to Water (feet)[b]	Well Yield (gpm)[b]
T17N R03W Sec 07	3	142	Unknown	NA	NA
		145	Domestic	NA	NA
		180	Domestic	NA	125
T17N R03W Sec 08	5	200	Domestic	15	75
		450	Test Hole	NA	NA
		70	Domestic	NA	NA
		151	Domestic	NA	NA
		240	Domestic	NA	200
T17N R03W Sec 17	3	390	Irrigation	15	NA
		100	Domestic	NA	NA
		400	Domestic	NA	200
T17N R03W Sec 18	1	160	Domestic	NA	70
T17N R04W Sec 11	1	240	Industrial	20	14
T17N R04W Sec 12	2	80	Domestic	41	11
		320	Test Hole	NA	NA
T17N R04W Sec 16	1	124	Domestic	17	12
T17N R04W Sec 26	1	180	Unknown	NA	NA

[a]The number of wells within a 1-mile radius of the project feature were determined based on the Township/Range/Sections falling within 1 mile of the project feature.

[b]Depth to water and well yield values are based on estimates provided by the driller at the time of drilling in well completion reports.

Source: DWR, 2011; Senter, 2017, pers. comm.

Glenn-Colusa Irrigation District Canal

Local Hydrogeology

The GCID Main Canal (proposed modifications) crosses deposits of the Riverbank Formation and basin deposits. The Riverbank Formation is composed of terrace deposits that consist of poorly consolidated gravel, sand, and silt. These deposits are found along the Sacramento River and adjacent tributaries and are up to 200 feet thick. Permeability of the Riverbank Formation is moderate to high, and yields of domestic wells are moderate. Basin deposits consist of silt and clay deposited in low-lying floodplain areas adjacent to major streams. Permeability of basin deposits is generally low, and groundwater occurs in limited amounts.

Delevan Pipeline, Sites/Delevan Overhead Power Line, Delevan Pipeline Electrical Switchyard, Delevan Pipeline Intake/Discharge Facilities, and Delevan Discharge Facility

Local Hydrogeology

The Delevan Pipeline, Sites/Delevan Overhead Power Line, Delevan Pipeline Electrical Switchyard, Delevan Pipeline Intake/Discharge Facilities, and Delevan Discharge Facility would overlie the Great Valley Sequence, Riverbank Formation, and basin deposits.

The Great Valley Sequence consists of marine, clastic sedimentary rock consisting of siltstone, shale, sandstone, and conglomerate. The sequence has a maximum thickness of 15,000 feet. Groundwater resources from this formation are limited because of poor water-bearing and water quality characteristics.

The Riverbank Formation is composed of terrace deposits that consist of poorly consolidated gravel, sand, and silt. These deposits are found along the Sacramento River and adjacent tributaries and are up to 200 feet thick. Permeability of the Riverbank Formation is moderate to high, and yields of domestic wells are moderate.

Basin deposits consist of silt and clay deposited in low-lying floodplain areas adjacent to major streams. Permeability of basin deposits is generally low, and groundwater occurs in limited amounts.

Local Groundwater Infrastructure

There are approximately 97 wells that have been constructed and 13 test holes drilled within approximately 1 mile of the Delevan Pipeline construction area (DWR, 2011; Senter, 2017, pers. comm.). Table 10-5 presents a summary of well data for these wells including the number of wells, well depth, well use, depth to water, and well yield, for the appropriate township, range, and section. The data presented here are from the DWR well completion report data set. Data are reported as it was submitted by the well driller at the time of drilling and development. None of this data was verified by DWR staff and conditions may have changed since the time of drilling. Additional wells may be present in the study area that were not reported to DWR by the driller.

Table 10-5

Wells Located within 1 Mile of the Delevan Pipeline and Associated Facilities[a]

Section Number	Number of Wells within Section	Well Depth (feet)	Well Use	Depth to Water (feet)[b]	Well Yield (gpm)[b]
T17N R01W Sec 06	9	269	Unknown	NA	NA
		25	Test Hole	NA	NA
		25	Test Hole	NA	NA
		28	Test Hole	NA	NA
		25	Test Hole	NA	NA
		20	Test Hole	NA	NA
		146	Domestic	NA	NA
		111	Domestic	NA	NA
		311	Irrigation	NA	NA
T17N R01W Sec 07	12	185	Unknown	NA	NA
		164	Domestic	NA	NA
		120	Domestic	NA	NA
		118	Domestic	NA	NA
		190	Domestic	NA	80
		440	Domestic	NA	NA
		304	Irrigation	NA	NA
		302	Irrigation	NA	NA
		250	Irrigation	NA	NA
		246	Irrigation	NA	NA
		280	Irrigation	NA	2,500
		48	Domestic	NA	50

Section Number	Number of Wells within Section	Well Depth (feet)	Well Use	Depth to Water (feet)[b]	Well Yield (gpm)[b]
T17N R01W Sec 18	6	123	Domestic	NA	NA
		50	Domestic	NA	NA
		473	Irrigation	NA	NA
		210	Irrigation	NA	NA
		299	Irrigation	NA	NA
		110	Irrigation	NA	80
T17N R02W Sec 01	10	24	Unknown	NA	NA
		20	Unknown	NA	NA
		22	Unknown	NA	NA
		20	Unknown	NA	NA
		21	Unknown	NA	NA
		94	Domestic	NA	NA
		109	Industrial	NA	NA
		230	Irrigation	NA	NA
		230	Irrigation	NA	NA
		120	Irrigation	NA	NA
T17N R02W Sec 06	2	13	Unknown	NA	NA
		695	Irrigation	NA	NA
T17N R02W Sec 07	2	119	Domestic	NA	NA
		180	Domestic	NA	NA
T17N R02W Sec 12	4	600	Irrigation	NA	NA
		630	Domestic	23	5,105
		350	Unknown	NA	NA
		760	Irrigation	NA	5,000
T17N R02W Sec 13	11	20	Unknown	NA	NA
		25	Test Hole	NA	NA
		25	Test Hole	NA	NA
		25	Test Hole	NA	NA
		25	Test Hole	NA	NA
		25	Test Hole	NA	NA
		25	Test Hole	NA	NA
		75	Domestic	NA	NA
		140	Domestic	NA	300
		830	Domestic	NA	4,554
		146	Domestic	NA	100
T17N R02W Sec 15	3	260	Irrigation	NA	NA
		300	Irrigation	NA	4,000
		260	Irrigation	NA	1,500
T17N R02W Sec 16	1	26	Unknown	NA	NA
T17N R02W Sec 18	2	270	Domestic	NA	100
		700	Irrigation	NA	4,000

Section Number	Number of Wells within Section	Well Depth (feet)	Well Use	Depth to Water (feet)[b]	Well Yield (gpm)[b]
T17N R03W Sec 01	2	13	Unknown	NA	NA
		220	Irrigation	NA	NA
T17N R03W Sec 02	2	200	Domestic	NA	80
		215	Domestic	NA	75
T17N R03W Sec 03	6	200	Domestic	NA	200
		560	Domestic	NA	32
		470	Domestic	NA	50
		370	Domestic	NA	60
		190	Domestic	NA	NA
		832	Irrigation	NA	NA
T17N R03W Sec 05	1	130	Domestic	NA	NA
T17N R03W Sec 06	2	105	Domestic	NA	50
		115	Irrigation	NA	100
T17N R03W Sec 07	3	145	Domestic	NA	NA
		142	Unknown	NA	NA
		380	Domestic	NA	125
T17N R03W Sec 08	5	240	Domestic	6	200
		70	Domestic	NA	NA
		450	Test Hole	NA	NA
		200	Domestic	15	75
		151	Domestic	NA	NA
T17N R03W Sec 09	6	175	Domestic	NA	NA
		192	Domestic	NA	NA
		200	Domestic	NA	NA
		192	Domestic	NA	NA
		331	Domestic	NA	NA
		232	Irrigation	NA	NA
T17N R03W Sec 10	1	200	Domestic	NA	NA
T17N R03W Sec 11	3	292	Domestic	NA	NA
		103	Domestic	NA	NA
		120	Domestic	NA	NA
T17N R03W Sec 12	4	560	Domestic	30	NA
		284	Domestic	NA	NA
		675	Domestic	NA	NA
		13	Unknown	NA	NA
T17N R03W Sec 13	1	825	Unknown	NA	NA
T17N R03W Sec 14	2	35	Monitoring	NA	NA
		264	Domestic	NA	NA
T17N R03W Sec 15	1	210	Domestic	NA	100
T17N R03W Sec 16	2	396	Domestic	NA	NA
		180	Domestic	NA	NA

Section Number	Number of Wells within Section	Well Depth (feet)	Well Use	Depth to Water (feet)[b]	Well Yield (gpm)[b]
T17N R03W Sec 17	4	390	Irrigation	15	NA
		390	Irrigation	15	NA
		100	Domestic	NA	NA
		400	Domestic	NA	200
T17N R03W Sec 18	1	160	Domestic	NA	70
T17N R04W Sec 12	2	320	Test Hole	NA	NA
		80	Domestic	NA	NA

[a]The number of wells within a 1-mile radius of the project feature were determined based on the Township/Range/Sections falling within 1 mile of the project feature.

[b]Depth to water and well yield values are based on estimates provided by the driller at the time of drilling in well completion reports.

Source: DWR, 2011; Senter, 2017, pers. comm.

The well depths ranged from 13 feet to 832 feet. The reported data for well yields were limited, but ranged between 32 and 5,105 gpm. The depth to water measurements ranged between 6 and 30 feet bgs, with an average depth of 17 feet. The intended use of the wells reported on the well completion reports is as follows: 54 domestic, 26 irrigation, 15 unknown, 1 monitoring, 1 industrial, and 13 test holes (DWR, 2011; Senter, 2017, pers. comm.).

Terminal Regulating Reservoir, Terminal Regulating Reservoir Pumping/Generating Plant, Terminal Regulating Reservoir Electrical Switchyard, and Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir

Local Hydrogeology

The TRR, TRR Pumping/Generating Plant, TRR Electrical Switchyard, and GCID Main Canal Connection to the TRR would overlie Riverbank Formation and basin deposits.

The Riverbank Formation is composed of terrace deposits that consist of poorly consolidated gravel, sand, and silt. These deposits are found along the Sacramento River and adjacent tributaries and are up to 200 feet thick. Permeability of the Riverbank Formation is moderate to high, and yields of domestic wells are moderate.

Basin deposits consist of silt and clay deposited in low-lying floodplain areas adjacent to major streams. Permeability of basin deposits is generally low, and groundwater occurs in limited amounts.

Local Groundwater Infrastructure

There are approximately 18 wells that have been constructed and 2 test holes drilled within an approximate 1-mile radius of the proposed TRR (DWR, 2011; Senter, 2017, pers. comm.). Table 10-6 presents a summary of well data for these wells including the number of wells, well depth, well use, depth to water, and well yield, for the appropriate township, range, and section. The data presented here are from the DWR well completion report data set. Data are reported as they were submitted by the well driller at the time of drilling and development. None of this data was verified by DWR staff and conditions may have changed since the time of drilling. Additional wells may be present in the study area that were not reported to DWR by the driller.

Table 10-6
Wells Located within a 1-mile Radius of the Terminal Regulating Reservoir Complex[a]

Section Number	Number of Wells within Section	Well Depth (feet)	Well Use	Depth to Water (feet) [b]	Well Yield (gpm) [b]
T17N R03W Sec 05	1	130	Domestic	4	NA
T17N R03W Sec 06	2	105	Domestic	20	50
		115	Irrigation	NA	100
T17N R03W Sec 07	3	145	Domestic	6	NA
		142	Unknown	NA	NA
		380	Domestic	NA	125
T17N R03W Sec 08	5	240	Domestic	6	200
		70	Domestic	17	NA
		151	Domestic	20	NA
		200	Domestic	15	75
		450	Test Hole	NA	NA
T17N R03W Sec 17	4	400	Domestic	8	200
		100	Domestic	20	NA
		390	Irrigation	15	NA
		390	Irrigation	15	NA
T17N R03W Sec 18	1	160	Domestic	12	70
T17N R03W Sec 20	2	64	Domestic	NA	NA
		270	Irrigation	NA	NA
T17N R04W Sec 12	2	320	Test Hole	NA	NA
		80	Domestic	NA	NA

[a]The number of wells within a 1-mile radius of the project feature were determined based on the Township/Range/Sections falling within 1e mile of the project feature.

[b]Depth to water and well yield values are based on estimates provided by the driller at the time of drilling in well completion reports.

Source: DWR, 2011; Senter, 2017, pers. comm.

The well depths ranged from 64 feet to 400 feet. The reported data for well yields were limited, but ranged between 50 and 200 gpm. The depth to water measurements ranged between 4 and 20 feet bgs with an average depth of 13 feet. Of the 18 wells listed in Table 10-6, 13 are used for domestic water supply, 4 are used for irrigation water supply, and one was listed as an unknown use (DWR, 2011; Senter, 2017, pers. comm.).

Project Buffer

Local Hydrogeology

The Project Buffer would surround groupings of Project facilities. The Project Buffer, therefore, would overlie the same formations and deposits as described for each of the Project facilities that are surrounded by the Project Buffer.

Local Groundwater Infrastructure

The Project Buffer extends from the Project facility footprints to the edge of the nearest land parcel; the distance of the Project Buffer boundary from any facility footprint is less than 1 mile. The well data presented for the Project facilities includes all wells located within 1 mile of the facilities and, therefore, includes wells that are located within the buffer boundary.

10.3 Environmental Impacts/Environmental Consequences

10.3.1 Evaluation Criteria and Significance Thresholds

Significance criteria represent the thresholds that were used to identify whether an impact would be potentially significant. Appendix G of the *CEQA Guidelines* suggests the following evaluation criterion for hydrology and water quality that is relevant to groundwater resources:

Would the Project:

- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted)?

The evaluation criteria used for this impact analysis represent a combination of the Appendix G criteria and professional judgment that considers current regulations, standards, and/or consultation with agencies, knowledge of the area, and the context and intensity of the environmental effects, as required pursuant to the National Environmental Policy Act. For the purposes of this analysis, an alternative would result in a potentially significant impact if it would result in any of the following:

- Substantial depletion of groundwater supplies or substantial interference with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of preexisting nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted).
- Increases in groundwater levels such that there would be adverse effects on environmental conditions, existing land uses, or planned uses for which permits have been granted.

10.3.2 Impact Assessment Assumptions and Methodology

Combinations of Project facilities were used to create Alternatives A, B, C, C_1, and D. In all resource chapters, the Authority and the Bureau of Reclamation described the potential impacts associated with the construction, operation, and maintenance of each of the Project facilities for each of the five action alternatives. Some Project features/facilities and operations (e.g., reservoir size, overhead power line alignments, provision of water for local uses) differ by alternative and are evaluated in detail within each of the resource area chapters. As such, the Authority has evaluated all potential impacts with each feature individually and may choose to select or combine individual features as determined necessary.

Impacts associated with the construction, operation, and maintenance for Alternative C_1 would be the same as those for Alternative C and are therefore not discussed separately below.

10.3.2.1 Assumptions

The following assumptions were made regarding Project-related construction, operation, and maintenance impacts on groundwater resources:

- Direct Project-related construction, operation, and maintenance activities would occur in the Primary Study Area.

- Direct Project-related operational activities would occur in the Secondary Study Area.
- The only direct Project-related construction activity that would occur in the Secondary Study Area is the installation of two additional pumps into existing bays at the Red Bluff Pumping Plant.
- The only direct Project-related maintenance activity that would occur in the Secondary Study Area is the sediment removal and disposal at the two intake locations (i.e., GCID Main Canal Intake and Red Bluff Pumping Plant).
- No direct Project-related construction or maintenance activities would occur in the Extended Study Area.
- Direct Project-related operational activities that would occur in the Extended Study Area are related to San Luis Reservoir operation, increased reliability of water supply to agricultural, municipal, and industrial water users; and the provision of an alternate Level 4 wildlife refuge water supply. Indirect effects on the operation of certain facilities that are located in the Extended Study Area, and indirect effects on the consequent water deliveries made by those facilities, would occur as a result of implementing the alternatives.
- The existing bank protection located upstream of the proposed Delevan Pipeline Intake/Discharge Facilities would continue to be maintained and remain functional.
- No additional channel stabilization, grade control measures, or dredging in the Sacramento River at or upstream of the Delevan Pipeline Intake/Discharge Facilities would be required.
- Project construction, operation, and maintenance activities will be performed after obtaining the appropriate clearances and permits (such as waste discharge requirement permits from the Central Valley Regional Water Quality Control Board).

10.3.2.2 Methodology

Existing conditions and the future No Project/No Action alternatives were assumed to be similar in the Primary Study Area given the generally rural nature of the area and limited potential for growth and development in Glenn and Colusa counties within the 2030 study period used for this EIR/EIS, as further described in Chapter 2 Alternatives Analysis. As a result, within the Primary Study Area, it is anticipated that the No Project/No Action Alternative would not entail material changes in conditions as compared to the existing conditions baseline.

With respect to the Secondary and Extended Study Areas, the effects of the proposed action alternatives would be primarily related to changes to available water supplies in the Secondary and Extended study areas, the Project's cooperative operations with other existing large reservoirs in the Sacramento watershed, and the resultant potential impacts and benefits to biological resources, land use, recreation, socioeconomic conditions, and other resource areas. DWR has projected future water demands through 2030 conditions that assume the vast majority of CVP and SWP water contractors would use their total contract amounts, and that most senior water rights users would use most of their water rights. This increased demand in addition to the projects currently under construction and those that have received approvals and permits at the time of preparation of the EIR/EIS would constitute the No Project/No Action Condition. As described in Chapter 2 Alternatives Analysis, the primary difference in these projected water demands would be in the Sacramento Valley, and as of the time of preparation of this EIR/EIS, the water demands have expanded to the levels projected to be achieved on or before 2030.

Accordingly, existing conditions and the No Project/No Action alternatives are assumed to be the same for this EIR/EIS and as such are referred to as the Existing Conditions/No Project/No Action Condition, which is further discussed in Chapter 2 Alternatives Analysis. With respect to applicable reasonably foreseeable plans, projects, programs, and policies that may be implemented in the future but that have not yet been approved, these are included as part of the analysis of cumulative impacts in Chapter 35 Cumulative Impacts.

Extended Study Area

Project-related operational impacts in the Extended Study Area include reoperation of reservoirs and water conveyance facilities associated with the SWP and CVP. The potential impact of these activities on groundwater resources was assessed qualitatively, considering the timing, magnitude, and duration of the activities.

Secondary Study Area

Operational Impacts Assessment

The surface water and groundwater systems are strongly connected in the Primary and Secondary (Sacramento Valley Groundwater Basin) study areas and are highly variable spatially and temporally. Within the Sacramento Valley Groundwater Basin, the Sacramento and Feather rivers act as drains and are recharged by groundwater throughout most of the year. The exceptions are areas of depressed groundwater elevations attributable to groundwater pumping (inducing leakage from the rivers) and localized recharge to the groundwater system. In contrast, the upper reaches of tributary streams flowing into the Sacramento River from upland areas are almost all losing streams (they recharge the groundwater system). Some of these transition to gaining streams (they receive groundwater) farther downstream, closer to their confluences with the Sacramento River. Estimates of these surface water and groundwater exchange rates have been developed for specific reaches on a limited number of streams in the Sacramento Valley Groundwater Basin (U.S. Geological Survey [USGS], 1985), but a comprehensive Valley-wide accounting has not been performed to date. Changes in operation of the surface water conveyance and distribution system will result in changes in the nature and magnitude of the interaction between the Sacramento River and the underlying aquifer system.

Potential changes in groundwater and surface water interaction were evaluated using a combination of CALSIM II and the Central Valley Hydrologic Model (CVHM) (USGS, 2009). CALSIM II is a surface water operations model used to simulate operation of the SWP and CVP water management. Technical details regarding the application and results of surface water modeling are provided in Chapter 6. Output from CALSIM II includes monthly discharge estimates for key points within the CVP and SWP systems (such as reservoir releases and stream diversions) from water year 1922 through 2003 (82-year simulation period). CVHM is a three-dimensional integrated groundwater and surface water model covering the Central Valley of California (Redding Groundwater Basin, Sacramento Valley Groundwater Basin, San Joaquin Groundwater Basin, and the Sacramento-San Joaquin Delta). The numerical tool simulates groundwater and surface water flows within the Central Valley resulting from varying climatic/hydrologic conditions, water demands (both agricultural and urban), and the supply process between 1961 and 2003. A detailed technical discussion of the application of the CVHM is provided in Appendix 10A Groundwater Modeling.

As discussed in Chapter 6, key changes in surface water operations in the Primary and Secondary study areas include changes in the flow at the TCCA and GCID diversions. The timing and magnitude of discharge changes at these diversions vary among the alternatives but generally include periods of increased diversion flow during certain months to fill or maintain the reservoirs, and reductions in flow during specific months as agricultural needs of local users would be met by reservoir releases rather than by Sacramento River water being diverted from the TCCA or GCID diversions. As described in Chapter 3, Alternatives A, C, and D include a new diversion on the Sacramento River (Delevan Pipeline Intake/Discharge Facilities). Monthly estimates of flow for the TCCA, GCID, and Delevan diversions and releases from the reservoirs that replace local groundwater demands for the Existing Conditions/No Project/No Action Condition and Alternatives A, B, C, and D were output from CALSIM II. These data were used as input in the surface water or agricultural water budget components of CVHM. Individual CVHM simulations were performed for the Existing Conditions/No Project/No Action Condition and Alternatives A, B, C, and D. CVHM output for Alternatives A, B, C, and D were compared to the Existing Conditions/No Project/No Action Condition to evaluate the timing and magnitude of changes in groundwater/surface water interaction and groundwater elevations. A detailed technical discussion of the application of CVHM is provided in Appendix 10A Groundwater Modeling.

Primary Study Area

Construction Impact Assessment

Activities that may affect groundwater resources include excavation requiring dewatering during construction of project facilities. Groundwater moves through the subsurface from a place of groundwater recharge to a place of groundwater discharge. When a pump is operated and lifts water to the land surface (such as for the purposes of dewatering), it is removing groundwater from aquifer storage and intercepting groundwater that would have otherwise moved to a different place of groundwater discharge. Thus, groundwater temporarily discharged from a groundwater well is initially removed from storage in the aquifer, which is eventually balanced by a temporary loss of water from somewhere else. The decline in the water level inside the pumping well creates a hydraulic gradient (slope) toward the well within the surrounding groundwater system outside the well. This slope causes groundwater from the surrounding groundwater system to flow radially (laterally and vertically) to the well, resulting in a declining water table (unconfined aquifer) or potentiometric surface (confined aquifer) in the surrounding aquifer. The feature formed by the decline in surrounding groundwater levels from groundwater pumping is referred to as the cone of depression. Operation of existing production wells located within the cone of depression and streams that overlie this cone of depression have the potential to be adversely affected. Potential impacts of construction-related dewatering during construction on groundwater resources were estimated qualitatively based on the number and location of wells with the potential to be impacted (Tables 10-2 through 10-6) by construction activities.

Operational Impact~~s~~ Assessment

The construction and operation of new reservoirs would result in inundation of new land within the Primary Study Area. A portion of the water retained in these reservoirs will infiltrate into the underlying subsurface materials, acting as new sources of recharge to the underlying groundwater system. Additional recharge could result in increases in groundwater levels in the aquifer system in the vicinity of the proposed Sites and Holthouse reservoirs. In the nearby Colusa Subbasin, additional groundwater recharge would be beneficial during dry periods when groundwater levels are generally low but could adversely affect adjacent land uses susceptible to seepage within the Primary Study in wetter years when groundwater levels are generally higher.

Potential direct Project-related impacts resulting from reservoir operation on groundwater resources within the Primary and Secondary (the Sacramento Valley Groundwater Basin) study areas were evaluated using a combination of analytical and numerical methods. Potential impacts of long-term reservoir seepage on groundwater resources were forecast using a numerical groundwater flow model, known as the Sacramento Valley Finite-Element Groundwater Model ($SACFEM_{2013}$) (CH2M and MBK Engineers, 2014). SACFEM is composed of a groundwater model and a surface water budgeting module that computes the monthly agricultural pumping and groundwater recharge resulting from applied water and precipitation. The model is calibrated to groundwater levels measured in monitoring wells during a 40-year period (water years[1] 1970 through 2010). Appendix 10A Groundwater Modeling provides a discussion of technical details associated with the project simulations using $SACFEM_{2013}$. Because the Sites Reservoir footprint and the majority of the Holthouse Reservoir footprint fall outside of the existing $SACFEM_{2013}$ model domain, potential seepage from these reservoirs was computed external to the numerical model using an analytical solution. The potential seepage calculation was based on the maximum planned operational stages, the groundwater elevation at the margin of the Colusa Subbasin in the vicinity of existing Funks Reservoir, the distance from the Sites or Holthouse reservoirs to the margin of the Colusa Subbasin (based digital elevation model grid cells [USGS, 2017]) in the vicinity of the existing Funks Reservoir, and published permeabilities for subsurface materials. Evaluation of seepage under maximum reservoir stage is considered conservative because this condition represents the largest elevation difference with respect to the underlying groundwater system (therefore, the largest potential seepage rate). The TRR will be constructed with a liner system to prevent seepage; therefore, evaluation of potential impacts associated with this facility involved computation of reduction in recharge to the groundwater system.

The potential change in groundwater levels within the Sacramento Valley Groundwater Basin resulting from computed seepage from the Sites and Holthouse reservoirs were then evaluated with $SACFEM_{2013}$. $SACFEM_{2013}$ includes a 40-year transient simulation period with varying hydrologic conditions. For the purposes of this evaluation, estimated reservoir seepage was simulated in $SACFEM_{2013}$ for the first 17 years of the simulation period (water year 1970 through water year 1985). This simulation period was considered appropriate for this evaluation because it included a critical drought (water years 1976 and 1977) and the wettest year in the simulation period (water year 1983). The baseline groundwater levels (the Existing Conditions/No Project/No Action Condition) are the model output from the $SACFEM_{2013}$ simulation described and documented in CH2M and MBK Engineers (2014). A second simulation was performed assigning additional inflow along the portion of the western model boundary downgradient from the Sites and Holthouse reservoirs (to represent shallow groundwater flowpaths with more lateral movement), consistent with the computed seepage from the Sites and Holthouse reservoirs for Alternative B. Because the Sites Reservoir footprint and maximum operating stages under Alternative A are smaller than for Alternative B, if potential Alternative B impacts were found to be less than significant, those for Alternative A would also be less than significant (because they would be smaller). Because the reservoir configurations for Alternatives C and D are the same as those for Alternative B, potential impacts would be the same. The model forecast groundwater elevations from the Existing Conditions/No Project/No Action Condition and Alternative B simulations were compared to evaluate the magnitude and distribution of the potential increase in groundwater elevation in the Sacramento Valley Groundwater Basin. Data are presented for the shallow portions of the aquifer system because this represents zones where increases in groundwater levels could affect shallow root zones in agricultural

[1] A water year runs from October 1 of the previous calendar year through September 30 of the current calendar year (e.g., water year 1976 includes the period of October 1, 1975, through September 30, 1976).

areas, wetlands, or wildlife areas. Spring 2016 depth to groundwater measurements, collected as part of the semi-annual DWR groundwater level monitoring program, are provided for context (DWR, 2017a). Spring generally represents the period of seasonally high groundwater (i.e., shallowest depth to water) in the Sacramento Valley Groundwater Basin. Appendix 10A Groundwater Modeling provides a discussion of technical details associated with the Project simulations using $SACFEM_{2013}$.

10.3.3 Topics Eliminated from Further Analytical Consideration

No Project facilities or topics that are included in the significance criteria listed above were eliminated from further consideration in this chapter.

10.3.4 Impacts Associated with Alternative A

10.3.4.1 Extended Study Area – Alternative A

Construction, Operation, and Maintenance Impacts

Agricultural, Municipal, Industrial, and Wildlife Refuge Water Use

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

There would be no Project construction or maintenance activities in the Extended Study Area; therefore, there would be **no impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

There would be no Project operational activities or results from those activities that would result in a substantial depletion of groundwater supplies in the Extended Study Area. As discussed in Chapter 6 (Tables 6-5 and 6-6), over the long term, CVP and SWP surface water supply reliability for agricultural, municipal, and industrial water users would be similar or increase slightly under Alternative A as compared to the Existing Conditions/No Project/No Action Condition. Wildlife Refuge Level 2 deliveries would increase in the Sacramento Valley and remain the same San Joaquin Valley and in the Tulare Lake Region as compared to the Existing Conditions/No Project/No Action Condition. Water acquisitions to meet the Wildlife Refuge Level 4 supply goals would be reduced as the substitute supply from the Project becomes available, and total Wildlife Refuge Level 4 supplies would increase as compared to the Existing Conditions/No Project/No Action Condition. During dry and critical water years, there would be similar or slightly increased agricultural and M&I deliveries. As a result, the Project would reduce the need for extracting groundwater and/or provide some additional applied water for deep percolation recharge of the aquifer system; groundwater supplies would, therefore, not be depleted or reduced. Therefore, increased surface water supply reliability would have a **beneficial impact** on groundwater resources in the Extended Study Area when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Improvement in surface water supply reliability for agricultural, municipal, and industrial water users as a result of the Project could result in stabilization or modest increases in groundwater resources in CVP/SWP areas because of slightly increased recharge rates and/or a reduced need for groundwater extraction. Therefore, increased surface water supply reliability would have a **beneficial impact** on groundwater resources for agricultural, municipal, and industrial water uses in the Extended Study Area, and could have a **beneficial impact** on groundwater resources for wildlife refuge water use in the Extended Study Area when compared to the Existing Conditions/No Project/No Action Condition.

San Luis Reservoir

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

CALSIM II operational modeling for Alternative A (described in Chapter 6), when compared to the Existing Conditions/No Project/No Action Condition, indicates that there would be continued water level fluctuations at San Luis Reservoir. San Luis Reservoir currently experiences severe water level fluctuations, and groundwater levels are not expected be substantially affected by continued fluctuations and would have **no impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion. Increased fluctuations in water levels at San Luis Reservoir would not be expected to result in a potentially significant increase in groundwater levels as compared to the Existing Conditions/No Project/No Action Condition and would, therefore, have **no impact** on groundwater resources.

10.3.4.2 Secondary Study Area – Alternative A

Construction, Operation, and Maintenance Impacts

Trinity Lake, Lewiston Lake, Trinity River, Klamath River Downstream of the Trinity River, Whiskeytown Lake, Spring Creek, Shasta Lake, Sacramento River, Keswick Reservoir, Clear Creek, Lake Oroville, Thermalito Complex (Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay), Feather River, Sutter Bypass, Yolo Bypass, Folsom Lake, Lake Natoma, American River, Sacramento-San Joaquin Delta, Suisun Bay, San Pablo Bay, San Francisco Bay

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

There are no Project-related construction, operation, or maintenance activities that would result in a substantial depletion of groundwater supplies in the Secondary Study Area. Project operational activities would generally result in similar to slightly increased end-of-month storage in reservoir facilities within the Secondary Study Area, when compared to the Existing Conditions/No Project/No Action Condition, which could increase infiltration that recharges groundwater in that area. During dry and critical water years, there would be similar or slightly increased agricultural and M&I deliveries. As a result, the Project would reduce the need for extracting groundwater and/or provide some additional applied water for deep percolation recharge of the aquifer system; groundwater supplies would, therefore, not be depleted or reduced. Therefore, increased surface water supply reliability would have a **beneficial impact** on groundwater resources in the Secondary Study Area when compared to the Existing Conditions/

No Project/No Action Condition. A detailed discussion of the estimated changes to the CVP and SWP are provided in Chapter 6.

Changes in reservoir storage would have a **beneficial impact** on groundwater resources within the Secondary Study Area when compared to the Existing Conditions/No Project/No Action Condition. Construction, operation, and maintenance of two additional pumps at the Red Bluff Pumping Plant would have **no impact** on groundwater resources when compared to the Existing Conditions/No Project/ No Action Condition because it would not extract groundwater.

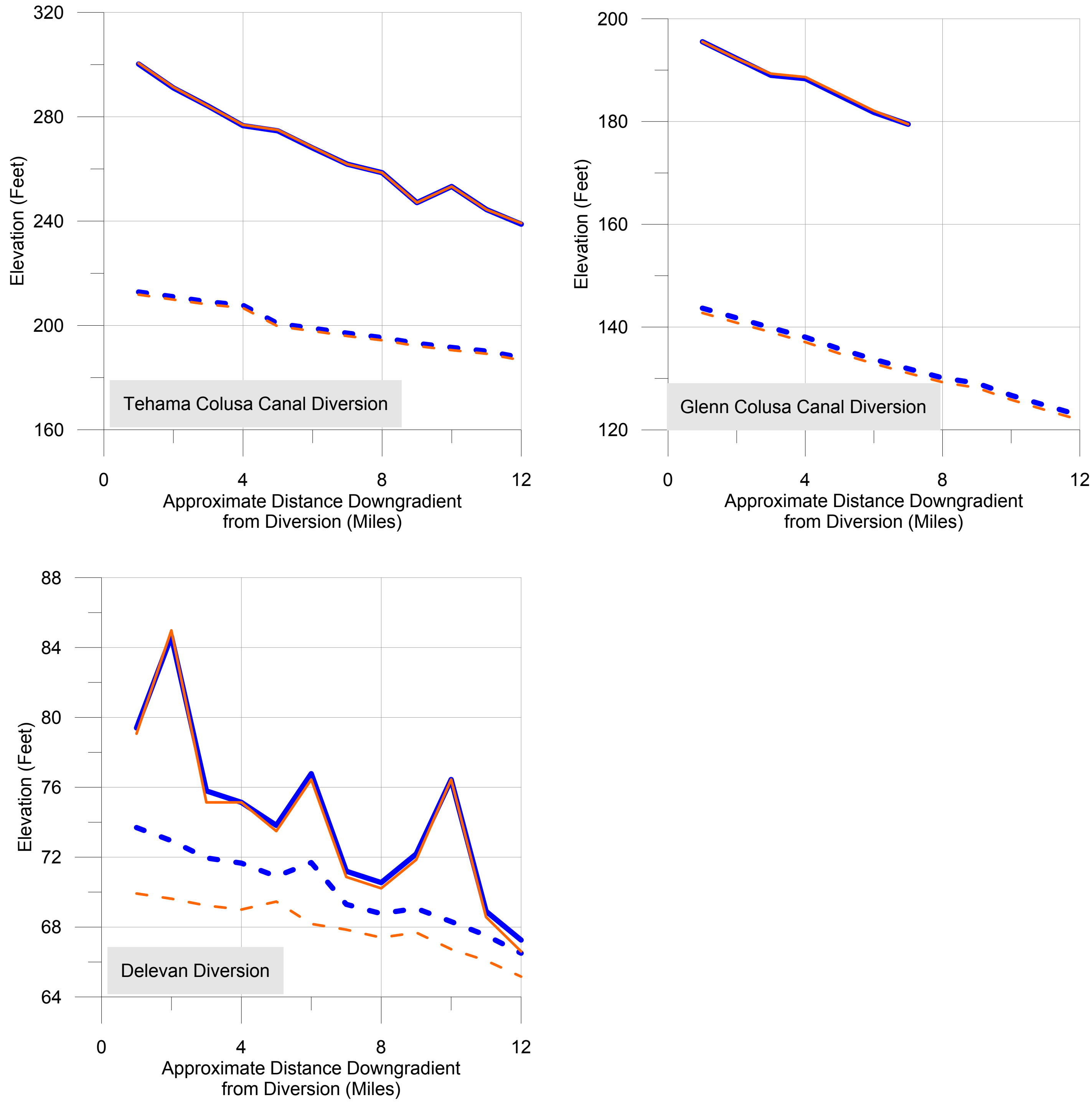
The potential impact of Project diversions at the Red Bluff Pumping Plant and GCID Main Canal intakes, and Delevan Pipeline Intake/Discharge Facilities on groundwater/surface water interaction and groundwater levels as compared to the Existing Conditions/No Project/No Action Condition were evaluated using a combination of CALSIM II and CVHM. Figure 10-6A presents plots of CVHM-simulated Sacramento River stage and underlying groundwater elevations with distance for the three diversions associated with Project operations. As shown on Figure 10-6A, the simulated Sacramento River stages and groundwater elevations for the Existing Conditions/No Project/No Action Condition and Alternative A are similar (Alternative A simulated stages are nearly identical, and groundwater elevations are as much as 1.1 feet lower) for the Red Bluff Pumping Plant and GCID Main Canal intakes.

For the Delevan Pipeline Intake/Discharge Facilities, CVHM simulations show that stream stage for Alternative A is less than 1 foot lower than the Existing Conditions/No Project/No Action Condition, and groundwater elevations for Alternative A are as much as 3.8 feet lower compared to the Existing Conditions/No Project/No Action Condition. Figure 10-6B presents plots of changes in groundwater/surface water interaction over time at three distances downstream from the diversions. CVHM results show that for Alternative A, there would be no appreciable change in groundwater recharge at the Red Bluff Pumping Plant and GCID Main Canal intakes compared to the Existing Conditions/No Project/No Action Condition. The average annual volumetric difference in groundwater/surface water exchange between the Existing Conditions/No Project/No Action Condition and Alternative A is forecasted by the CVHM to be 0.25 percent at Tehama-Colusa Canal Intake, and 2 percent at GCID Main Canal Intake.

At the Delevan Pipeline Intake/Discharge Facilities under Alternative A, groundwater recharge would be similar to the Existing Conditions/No Project/No Action Condition. The average annual volumetric difference in groundwater/surface water exchange between the Existing Conditions/No Project/No Action Condition and Alternative A is forecasted by the CVHM to be 0.44 percent at the Delevan Pipeline Intake/Discharge Facilities. Because the model forecast changes in the Sacramento River stage, underlying groundwater elevations, and groundwater/surface water interaction under Alternative A are negligible to minor as compared to the Existing Conditions/No Project/No Action Condition, impacts would be **less than significant** in the Secondary Study Area.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

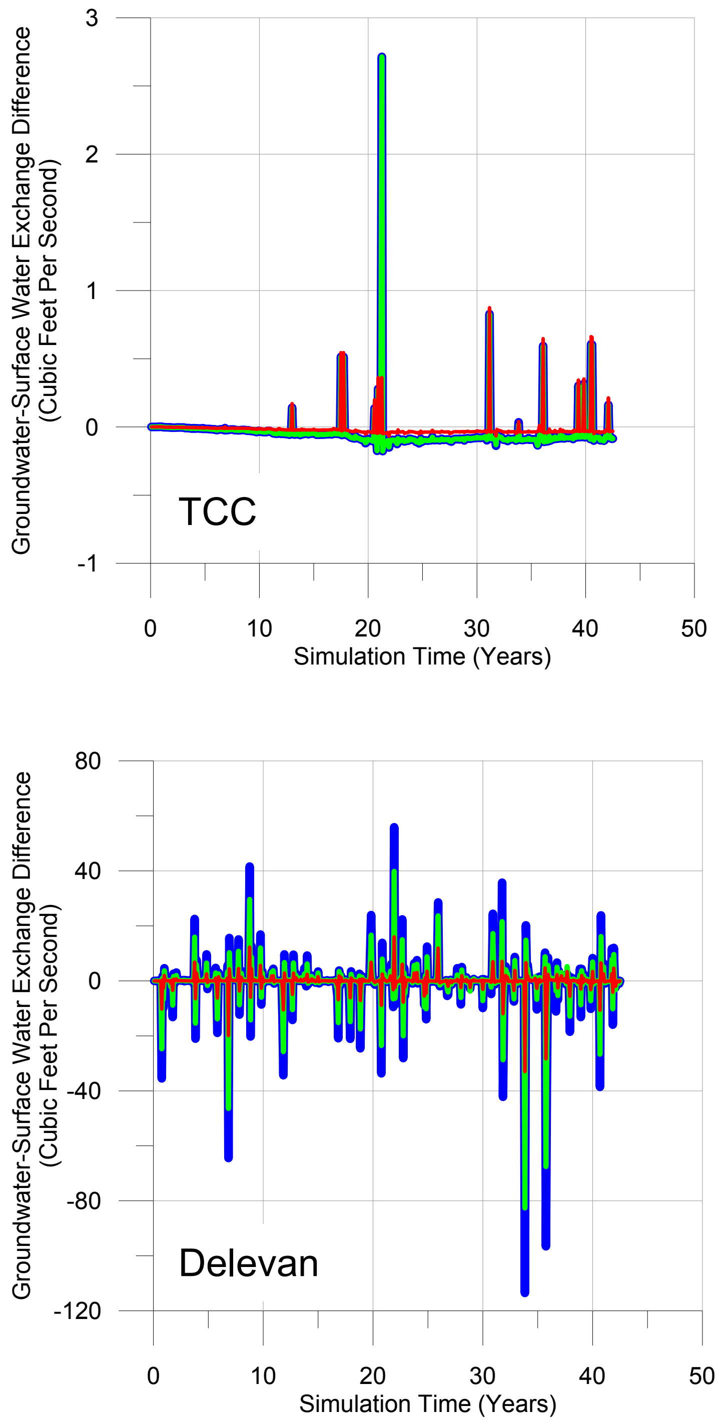
Refer to the **Impact GW Res-1** discussion.



Legend

River Stage, No Action Alternative
Groundwater Elevation, No Action Alternative
River Stage, Alternative A
Groundwater Elevation, Alternative A
NAA Existing Conditions/No Project/No Action Condition

FIGURE 10-6A
CVHM-Forecast Sacramento River Stages and Groundwater Elevations after 24.8 Years for Alternative A and Existing Conditions/No Project/No Action Condition
Sites Reservoir Project EIR/EIS



Legend

- 5 Model Cells (~5 miles)
- 10 Model Cells (~10 miles)
- 12 Model Cells (~12 miles)

NAA	Existing Conditions/No Project/No Action Condition
TCC	Tehama-Colusa Canal Intake
GCC	GCID Canal Intake

FIGURE 10-6B
Groundwater-Surface Water Exchange Differences between Sites Alternative A and Existing Conditions/ No Project/No Action Condition
Sites Reservoir Project EIR/EIS

10.3.4.3 Primary Study Area – Alternative A

Construction, Operation, and Maintenance Impacts

Sites Reservoir Inundation Area

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

Construction and the initial filling of Sites Reservoir would completely inundate both the Funks and Antelope Creek groundwater basins. Approximately 26 groundwater wells (Senter, 2017, pers. comm.) located within the Alternative A inundation area would no longer be functional; however, there would no longer be any use for the wells after the reservoir is inundated.

Operation and maintenance activities would result in a wide fluctuation of water stored in the Sites Reservoir during the year when compared to the Existing Conditions/No Project/No Action Condition. Although the reservoir stage would fluctuate over time, the presence of a surface water body in previously unsaturated areas would result in additional recharge to the underlying groundwater system. As such, operation of the Sites Reservoir would not result in substantial depletion of groundwater supplies or substantial interference with groundwater recharge resulting in a net deficit in aquifer volume or a lowering of the local groundwater table level, causing effects on existing land uses or planned uses. Therefore, construction, operation, and maintenance of Sites Reservoir would have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Potential rates of seepage from the Sites Reservoir under the maximum Alternative A reservoir stage elevation of approximately 480 feet were estimated to be approximately 1,500 gpm. The potential impact of additional combined seepage from the Sites and Holthouse (an additional approximately 220 gpm) reservoir inundation areas on groundwater levels in the Sacramento Valley Groundwater Basin (Colusa Subbasin) were evaluated for Alternative B. Because the Sites Reservoir footprint under Alternative A would be smaller (1.3 million acre-feet [MAF]) and the maximum operating stage lower than for Alternative B, any associated benefit or adverse impact would be smaller for Alternative A than for Alternative B. As discussed in Section 10.3.5.3, increases in groundwater levels in response to Holthouse and Sites Reservoir seepage under Alternative B are considered **beneficial** in drier years because groundwater levels would be anticipated to rise. In wetter years when groundwater levels are closer to the surface, impacts are not anticipated to appreciably increase seepage and, as such, would be **less than significant** in wetter years as compared to the Existing Conditions/No Project/No Action Condition. Because increases in groundwater levels would be less under Alternative A, potential impacts are also **beneficial** in drier years and **less than significant** in wetter years as compared to the Existing Conditions/No Project/No Action Condition.

Sites Reservoir Dams

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

Golden Gate Dam, Sites Dam, and the seven saddle dams would be located outside of the Funks and Antelope Creek groundwater basins. Sites and Golden Gate dams would be constructed on Stone Corral and Funks creeks, respectively; flows to those creeks would be maintained during construction. Some redirection of creek flows and stormwater management during construction may result in very minor redirection of groundwater recharge when compared to the Existing Conditions/No Project/No Action Condition. Operation and maintenance activities of the dam structures would not impede groundwater recharge. Therefore, the construction, operation, and maintenance activities associated with these dams would have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion. Operation and maintenance activities of the dam structures would not significantly increase groundwater recharge. Therefore, the construction, operation, and maintenance activities associated with these dams would have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Recreation Areas

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

The recreation areas would be located outside of the Funks and Antelope Creek groundwater basins, and no deep subsurface construction would be required; therefore, their development would result in **no impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition. Groundwater would not be used during the construction and maintenance of, or as a potable water source for, the recreation areas. Therefore, the construction, operation, and maintenance activities associated with the recreation areas would have **no impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion.

Road Relocations and South Bridge

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

The construction, operation, and maintenance of these facilities would not require the use of groundwater. The addition of 46 miles of impermeable roads could slightly diminish groundwater recharge but not to an extent that would be expected to impact existing uses of nearby wells. These activities would, therefore, have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion. Localized lowering of the groundwater levels as a result of reduced groundwater recharge would not increase groundwater levels. The construction, operation, and maintenance of these facilities would therefore have **no impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Sites Pumping/Generating Plant, Electrical Switchyard, Tunnel, Reservoir Inlet/Outlet Structure, and Field Office Maintenance Yard

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

Construction of the Sites Pumping/Generating Plant, Sites Electrical Switchyard, Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure, and Sites Reservoir Inlet/Outlet Structure, and Field Office Maintenance Yard may require dewatering that could result in temporary, localized lowering of the groundwater levels. The anticipated total depth of excavation for the Sites Pumping and Generating Plant is 40 feet bgs (Barnes and Herrin, 2017, pers. comm.). As shown in Table 10-2, there are two wells located within approximately 1 mile of these facilities with total depths of 105 (stock well) and 124 feet bgs (domestic well) and depths to water of 7 and 17 feet bgs, respectively. It is not anticipated that temporary dewatering during construction would impact these wells and the construction, operation, and maintenance of these facilities would have a **less-than-significant impact** on groundwater resources compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion. Temporary localized lowering of the groundwater would not increase groundwater levels. Therefore, the construction, operation, and maintenance of these facilities would have **no impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Holthouse Reservoir Complex, Terminal Regulating Reservoir Pipeline, and Terminal Regulating Reservoir Pipeline Road

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

Construction and future maintenance of the Holthouse Reservoir Complex would require the dredging of the existing Funks Reservoir. Dredging activities would require the dewatering of Funks Reservoir for approximately 2 years, which would likely result in a short-term reduction in groundwater recharge in the local area. As shown in Tables 10-2 and 10-4, there are two wells located in this area with total depths of 124 (domestic well) and 240 feet bgs (industrial well) and depths to water of 17 and 20 feet bgs, respectively. It is not anticipated that temporary dewatering during construction would impact these wells and there would be a **less-than-significant impact** on groundwater resources from the dredging of Funks Reservoir when compared to the Existing Conditions/No Project/No Action Condition.

Construction of the Holthouse Reservoir Complex facilities, TRR Pipeline, and TRR Pipeline Road may require temporary dewatering, which could result in temporary, localized lowering of the groundwater levels in the vicinity of the construction area. The anticipated depth of the excavation for the TRR pipeline is 22 feet bgs (Barnes and Herrin, 2017, pers. comm.).-As shown in Table 10-4, there are 15 wells located within 1 mile of these facilities. These domestic, irrigation, industrial, and/or unknown use wells have total depths ranging from 70 to 400 feet bgs and depths to water ranging from 15 to 41 feet bgs. It is not anticipated that temporary dewatering during construction would impact these wells such that the construction, operation, and maintenance of these facilities would have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion. Dewatering Funks Reservoir would not increase groundwater levels. Therefore, there would be **no impact** on groundwater resources from the dredging of Funks Reservoir when compared to the Existing Conditions/No Project/No Action Condition.

Inundation of Holthouse Reservoir would likely lead to higher groundwater levels in a localized area around the reservoir. Potential rates of seepage from the Holthouse Reservoir under the maximum Alternative A reservoir stage elevation of approximately 206 feet were estimated to be approximately 220 gpm. As previously discussed, the potential impact of additional combined seepage from the Sites and Holthouse reservoir inundation areas on groundwater levels in the Sacramento Valley Groundwater Basin (Colusa Subbasin) were evaluated for Alternative B. Because the Sites Reservoir footprint under Alternative A will be smaller (1.3 MAF) and the maximum operating stage lower than for Alternative B, any associated benefit or adverse impact would be smaller for Alternative A than for Alternative B. As discussed in Section 10.3.5.3 increases in groundwater levels in response to Holthouse and Sites Reservoir seepage under Alternative B are considered **beneficial** in drier years and to **less than significant** in wetter years as compared to the Existing Conditions/No Project/No Action Condition. Because increases in groundwater levels would be smaller under Alternative A, potential impacts are also **beneficial** in drier years and **less than significant** in wetter years as compared to the Existing Conditions/No Project/No Action Condition.

Glenn-Colusa Irrigation District Canal Facilities Modifications

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

Construction of the new GCID Main Canal headgate structure is not anticipated to require temporary dewatering (Barnes and Herrin, 2017, pers. comm.). Therefore, construction, operation, and maintenance of the GCID Main Canal headgate structure would have a **no impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion.

Terminal Regulating Reservoir, Terminal Regulating Reservoir Pumping/Generating Plant, Terminal Regulating Reservoir Electrical Switchyard, and the Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

Construction of the TRR, TRR Pumping/Generating Plant, TRR Electrical Switchyard, and the GCID Main Canal Connection to the TRR (an energy dissipation bay and inlet channel) may require temporary dewatering, which could result in temporary, localized lowering of groundwater levels to allow for the installation of underground equipment in the construction area. The anticipated depth of the excavation for the TRR Pumping/Generating Plant is approximately 30 feet bgs, with sheetpiles likely being used (depending on the depth to competent bedrock) to reduce groundwater inflow to the excavation (Barnes and Herrin, 2017, pers. comm.). As shown in Table 10-6, there are 18 wells located within 1 mile of these facilities. These domestic, irrigation, and/or unknown use wells have total depths ranging from 64 to 400 feet bgs and depths to water ranging from 4 to 20 feet bgs. It is not anticipated that temporary dewatering during construction would impact these wells such that the construction, operation, and maintenance of these facilities would have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition

The TRR will be constructed with an ultra-violet-resistant polyvinylchloride or high-density polyethylene liner to minimize seepage over the 200-acre footprint. Conversion of approximately 200 acres of irrigated agriculture to a lined-reservoir would likely result in temporary lowering of groundwater levels as a result of the reduction in deep percolation of precipitation and applied water. The estimated deep percolation of precipitation over the TRR footprint under average hydrologic conditions (water year 2005) is estimated at approximately 225 acre-feet/year. This represents less than 0.1 percent of the average deep percolation within the Colusa Subbasin (400,700 acre-feet/year) included in $SACFEM_{2013}$ under average hydrologic conditions. Because the relative magnitude of groundwater recharge that would be lost is small as compared to conditions within the subbasin, operation and maintenance of these facilities would, therefore, have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion. Because the TRR will be constructed with an ultra-violet-resistant polyvinylchloride or high-density polyethylene liner to minimize seepage, there would not be an increase in groundwater levels because of seepage from the reservoir. Therefore, the construction, operation, and maintenance of these facilities would have **no impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Delevan Pipeline, Sites/Delevan Overhead Power Line, and Delevan Pipeline Electrical Switchyard

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

Construction of the Delevan Pipeline, Delevan Pipeline Electrical Switchyard, and Sites/Delevan Overhead Power Line tower footings may require temporary, localized dewatering, which could result in lowering of groundwater levels to allow for the installation of underground equipment in the construction area. The anticipated depth of the excavation for the Delevan Pipeline is 22 feet bgs (Barnes and Herrin, 2017, pers. comm.).-As shown in Table 10-5, there are 97 wells located within 1 mile of the pipeline disturbance area, 1 of which is a monitoring well. These domestic, irrigation, industrial, and/or unknown use wells have total depths ranging from 13 to 832 feet bgs and depths to water ranging from 6 to 30 feet bgs. It is not anticipated that temporary dewatering during construction would impact these wells such that the construction, operation, and maintenance of these facilities would have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion. Temporary localized lowering of the groundwater would not increase water levels, and therefore, would have **no impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

Delevan Pipeline Intake/Discharge Facilities

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

Construction, operation, and maintenance of the Delevan Pipeline Intake/Discharge Facilities would include construction of forebay/afterbay facilities, a fish screen, and a pumping and generating plant. The anticipated excavation depth for construction of the Delevan Pumping/Generating Plant at the intake facilities is approximately 38 feet bgs (Barnes and Herrin, 2017, pers. comm.). Additionally, as discussed in Chapter 3, a cellular sheetpile cofferdam would be installed to isolate the construction area from the Sacramento River and reduce inflow to the excavation. There are no wells included in the DWR water data library system within 1 mile of the Delevan Pipeline Intake/Discharge Facilities on the western side of the Sacramento River (DWR, 2017b). There are a number of PLSS parcels with wells within approximately 1 mile of the existing Delevan Pipeline Intake/Discharge Facilities on the eastern side of the Sacramento River with total depths ranging from 20 to 830 feet bgs. It is not anticipated that temporary dewatering during construction would impact these wells, particularly given that they are located on the eastern side of the Sacramento River (the major hydrologic feature in the area). such that there would be a **less-than-significant impact** on groundwater resources from construction of the Delevan Pipeline Intake/Discharge Facilities when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

As discussed in Chapter 3, the Delevan Pipeline Intake/Discharge Facilities will include construction and operation of a 1.3-acre unlined forebay and a 2.3 acre afterbay. Both of these facilities will be constructed with an ultra-violet-resistant polyvinylchloride or high-density polyethylene liner to minimize seepage (similar to the TRR). As such, there would be no increase in groundwater levels associated with seepage from these facilities; therefore no impact on adjacent orchard crops. Therefore, construction, operation, and maintenance of the Delevan Pipeline Intake/Discharge Facilities would, result in a **less-than-significant impact** to groundwater resources in the areas directly surrounding the forebay and afterbay facilities when compared to the Existing Conditions/No Project/No Action Condition.

Project Buffer

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

Within the Project Buffer, some structures would be demolished. Wells associated with those structures or used as irrigation sources may, therefore, no longer be used, resulting in the potential for some irrigated agricultural fields to no longer be irrigated. The discontinued use of wells or irrigation sources could increase, rather than decrease, groundwater supplies. Therefore, there would be **no impact** when compared to the Existing Conditions/No Project/No Action Condition.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion. The potential reduction in groundwater extraction rates related to the discontinued use of wells could increase groundwater supplies; however, the increase in groundwater levels would not result in an adverse effect on current groundwater uses in the area because the increase would be minimal and would not occur over an area wide enough to affect local groundwater users. Therefore, the acquisition of land within the Project Buffer would have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

10.3.5 Impacts Associated with Alternative B

10.3.5.1 Extended Study Areas – Alternative B

Construction, Operation, and Maintenance Impacts

Although there will be slight changes to the CVP and SWP water supplies (Tables 6-5 and 6-6) and San Luis Reservoir end-of-month storage (Section 6.3.3.1), the impacts associated with Alternative B as they relate to groundwater supplies, decreases in groundwater levels, (**Impact GW Res-1**) and increases in groundwater levels (**Impact GW Res-2**) would be the same as those described for Alternative A for the Extended Study Area.

10.3.5.2 Secondary Study Area – Alternative B

Construction, Operation, and Maintenance Impacts

The majority of the impacts associated with Alternative B as they relate to groundwater supplies, decreases in groundwater levels (**Impact GW Res-1**), and increases in groundwater levels (**Impact GW**

Res-2) would be the same as those described for Alternative A for the Secondary Study Area. The exception is the difference in operations of the SWP and CVP facilities between Alternatives A and B.

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

The potential impact of Alternative B project diversions at the Red Bluff Pumping Plant and GCID Main Canal diversions and Delevan Pipeline discharge facility on groundwater/surface water interaction and groundwater levels as compared to the Existing Conditions/No Project/No Action Condition were evaluated. Simulated groundwater elevations and Sacramento River stages downgradient from the Project diversions were compared at various times throughout the model simulation. Figure 10-7A presents plots of CVHM simulated Sacramento River stage and underlying groundwater elevations with distance for the two diversions and one discharge facility.

As shown on Figure 10-7A, the simulated Sacramento River stages and groundwater elevations for the Existing Conditions/No Project/No Action Condition and Alternative B were very similar (Alternative B simulated stages for Alternative B are almost identical to the Existing Conditions/No Project/No Action Condition, and groundwater elevations are up to 2.5 feet lower under Alternative B than for the Existing Conditions/No Project/No Action Condition) for the Red Bluff Pumping Plant and GCID Main Canal intakes. The average annual volumetric difference in groundwater/surface water exchange between the Existing Conditions/No Project/No Action Condition and Alternative B is forecasted by the CVHM to be 0.22 percent at the Tehama-Colusa Canal, and 2.3 percent at the Glenn-Colusa Canal. At the Delevan Pipeline discharge facility, CVHM simulations for Alternative B show a decrease in stream stage of up to 1 foot and a decrease in groundwater elevations of up to 5.5 feet.

Figure 10-7B presents plots of changes in groundwater/surface water interaction over time at three distances downstream from the diversions and discharge facility under Alternative B. Maximum projected increases of up to 3 cubic feet per second in groundwater recharge are simulated under Alternative B (compared to the Existing Conditions/No Project/No Action Condition) at the Red Bluff Pumping Plant. At the GCID Main Canal Intake, the changes in groundwater recharge under Alternative B would be similar to the Existing Conditions/No Project/No Action Condition. The average annual volumetric difference in groundwater/surface water exchange between the Existing Conditions/No Project/No Action Condition and Alternative B is forecasted by the CVHM to be 0.22 percent at Tehama-Colusa Canal Intake, and 2.3 percent at GCID Main Canal Intake. At the Delevan Pipeline discharge facility, increases and decreases in groundwater/surface water interaction would also be similar to the Existing Conditions/No Project/No Action Condition.

The average annual volumetric difference in groundwater/surface water exchange between the Existing Conditions/No Project/No Action Condition and Alternative B is forecast by the CVHM to be 0.32 percent at the Delevan Pipeline Discharge Facility. Because the model forecast changes in Sacramento River stage, underlying groundwater elevations, and groundwater/surface water interaction under Alternative B are negligible to minor as compared to the Existing Conditions/No Project/No Action Condition, impacts would be **less than significant** in the Secondary Study Area.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion.

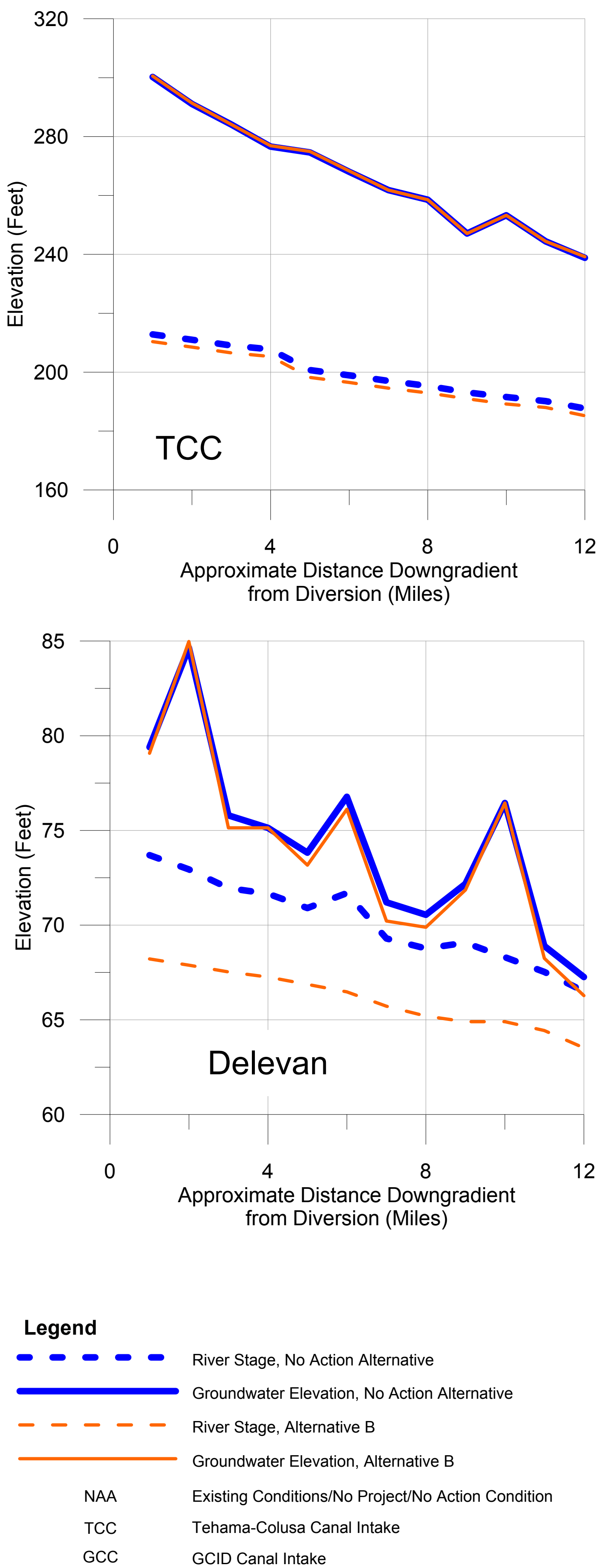
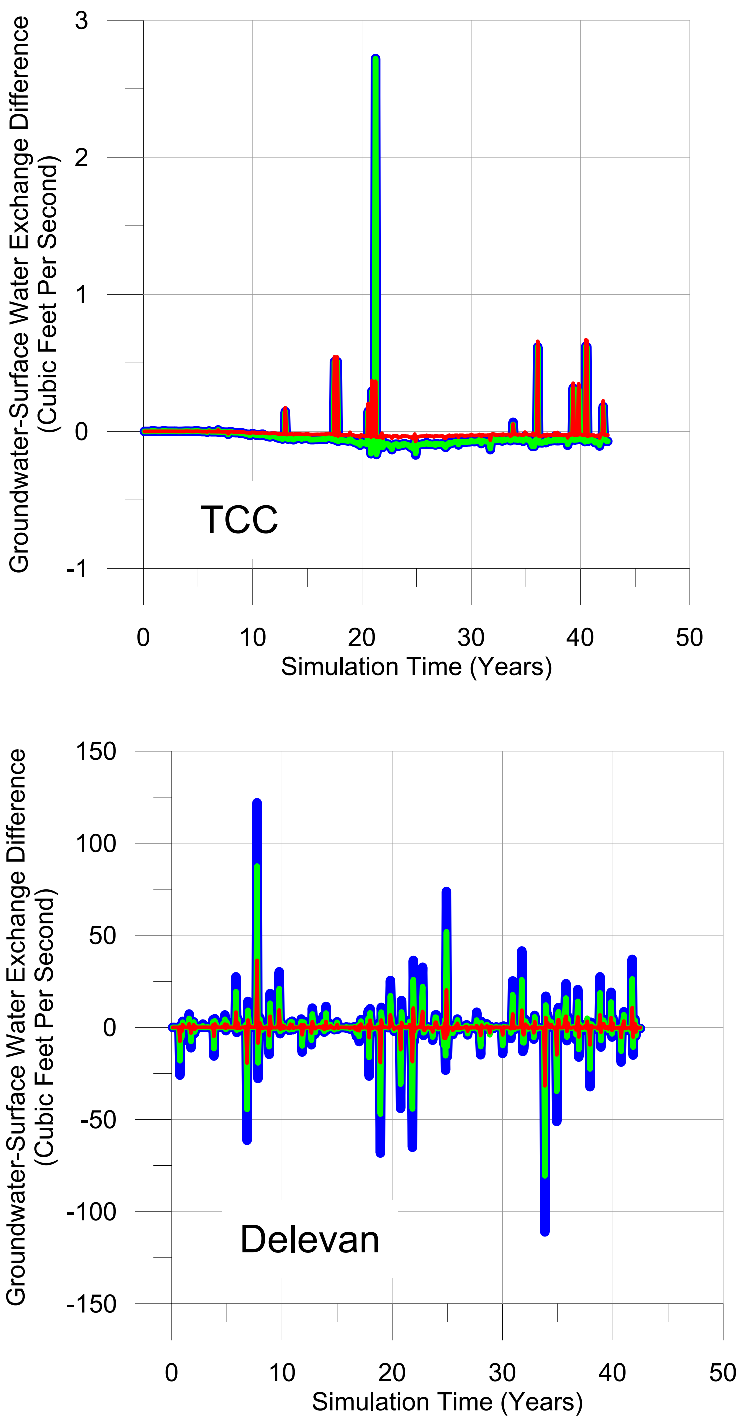


FIGURE 10-7A
CVHM-Forecast Sacramento River Stages and Groundwater Elevations after 24.8 Years for Alternative B and Existing Conditions/No Project/No Action Condition
Sites Reservoir Project EIR/EIS



Legend

5 Model Cells (~5 miles)
10 Model Cells (~10 miles)
12 Model Cells (~12 miles)
NAA Existing Conditions/No Project/No Action Condition

FIGURE 10-7B
Groundwater-Surface Water Exchange Differences between Sites Alternative B and Existing Conditions/No Project/No Action Condition
Sites Reservoir Project EIR/EIS

10.3.5.3 Primary Study Area – Alternative B

Construction, Operation, and Maintenance Impacts

The majority of the Project facilities would be the same for Alternatives A and B (see Chapter 3 Description of the Sites Reservoir Project Alternatives, Table 3-1). These facilities would require the same construction methods and operation and maintenance activities and would, therefore, result in the same construction and maintenance impacts on groundwater resources.

If Alternative B is implemented, the footprint and construction disturbance area of Sites Reservoir and Dams, the Road Relocations and South Bridge, and the Sites/Delevan Overhead Power Line would differ from Alternative A. In addition, the Delevan Pipeline Intake/Discharge Facilities would be replaced by a discharge only facility. The boundary of the Project Buffer would be the same for Alternatives A and B, but because the footprints of some of the Project facilities that are included in the Project Buffer would differ among the alternatives, the acreage of land within the Project Buffer would also differ.

However, these differences in the size of the facility footprint, alignment, or construction disturbance area would not change the type of construction, operation, and maintenance activities that were described for Alternative A. They would, therefore, have the same impact on groundwater supplies, decreases in groundwater levels (**Impact GW Res-1**), and increases in groundwater levels (**Impact GW Res-2**) as those described for Alternative A. Exceptions include the larger Sites Reservoir Inundation Area associated with Alternative B (1.8 MAF) and the exclusion of the potential impacts associated with the Delevan Pipeline Intake/Discharge Facility forebay and afterbay that are included in Alternative A but not in Alternative B.

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

As with Alternative A, construction and the initial filling of Sites Reservoir would completely inundate both the Funks and Antelope creek groundwater basins. Approximately 30 groundwater wells (Senter, 2017, pers. comm.) located within the Alternative B inundation area would no longer be functional; however, there would no longer be any use for the wells after the reservoir is inundated.

Similar to Alternative A, operation and maintenance activities would result in a wide fluctuation of water stored in the Sites Reservoir during the year when compared to the Existing Conditions/No Project/No Action Condition. Although the reservoir stage would fluctuate over time, the presence of a surface water body in previously unsaturated areas would not result in additional recharge to the underlying groundwater system. As such, operation of the Sites Reservoir would not result in substantial depletion of groundwater supplies or substantial interference with groundwater recharge resulting in a net deficit in aquifer volume or a lowering of the local groundwater table level, causing effects on existing land uses or planned uses. Therefore, construction, operation, and maintenance of Sites Reservoir would have a **less-than-significant impact** on groundwater resources when compared to the Existing Conditions/No Project/No Action Condition.

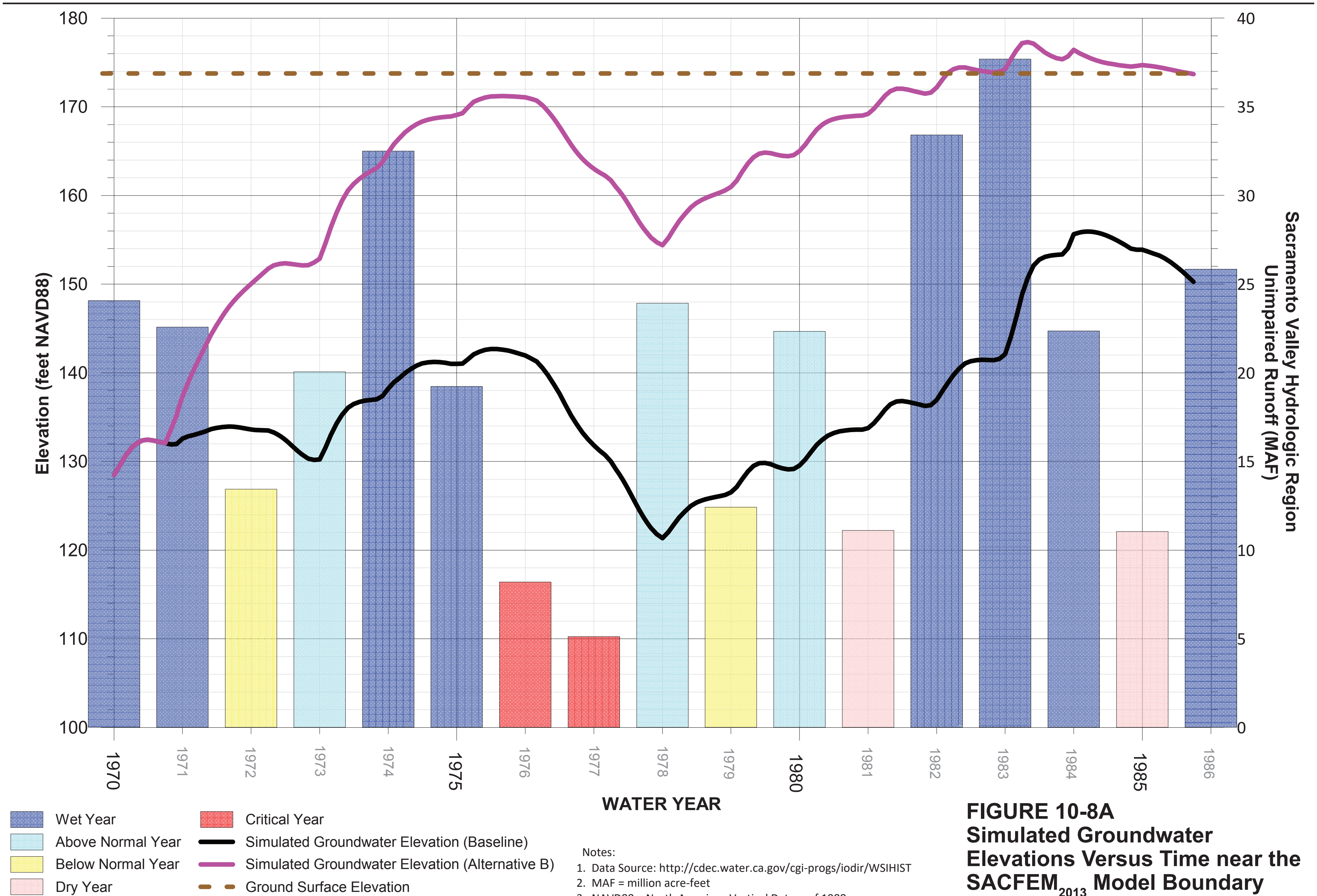
Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Potential rates of seepage from the Sites and Holthouse Reservoirs under the maximum Alternative B through D reservoir stage of approximately 520 feet and 206 feet, respectively, were estimated to be approximately 2,150 gpm (1,930 gpm for Sites Reservoir and 220 gpm for Holthouse Reservoir). Figures 10-8A and 10-8B present simulated Existing Conditions/No Project/No Action Condition and Alternative B groundwater elevations in the vicinity of the existing Funks Reservoir (the point with the largest increase in groundwater levels) and for a location within the orchards southeast of Funks Creek. Figures 10-8A and 10-8B also present bar charts representing the Sacramento Valley water year classification for the period simulated. These data show that following the onset of reservoir operation, simulated groundwater levels would begin to increase as compared to the Existing Conditions/No Project/No Action Condition. In most years the inflow to the groundwater system from reservoir seepage would provide a benefit in terms of additional groundwater. As shown on Figure 10-8A, groundwater levels are projected to be over 20-feet higher during critical drought years. During extremely wet hydrologic conditions, the increased groundwater levels may result in additional discharge to streams and/or low lying areas. Figure 10-8B presents hydrographs for a location within the orchards southeast of Funks creek where groundwater levels are projected to increase. These hydrographs indicate that even during extremely wet conditions, groundwater levels are forecast to be several feet bgs (at the highest simulated elevations).

Figures 10-9A and 10-9B present the simulated increases in groundwater levels in the shallow aquifer for hydraulic conditions consistent with February 1980 and April 1983, respectively. In addition to groundwater level increases, these figures present the spring 2016 depth to groundwater measurements for context. Figure 10-9A presents the distribution of simulated increase in groundwater levels for February 1980, which represents the period of maximum difference in groundwater elevations between Alternative B and the Existing Conditions/No Project/No Action Condition. These data suggest that groundwater levels could increase nearly 35 feet along the western $SACFEM_{2013}$ model boundary near Funks Creek.

Figure 10-9B presents the distribution of simulated increase in groundwater levels for April 1983, which represents the period of highest groundwater elevations during the wettest year in the simulation period. These data suggest that groundwater levels could increase over 25 feet along the western $SACFEM_{2013}$ model boundary near Funks Creek. As shown on Figures 10-9A and 10-9B, the distribution of larger magnitude increases in groundwater levels is restricted to the western margin of the Colusa Subbasin, with model forecast increase in groundwater levels of less than 0.5 foot over most of the Primary Study Area.

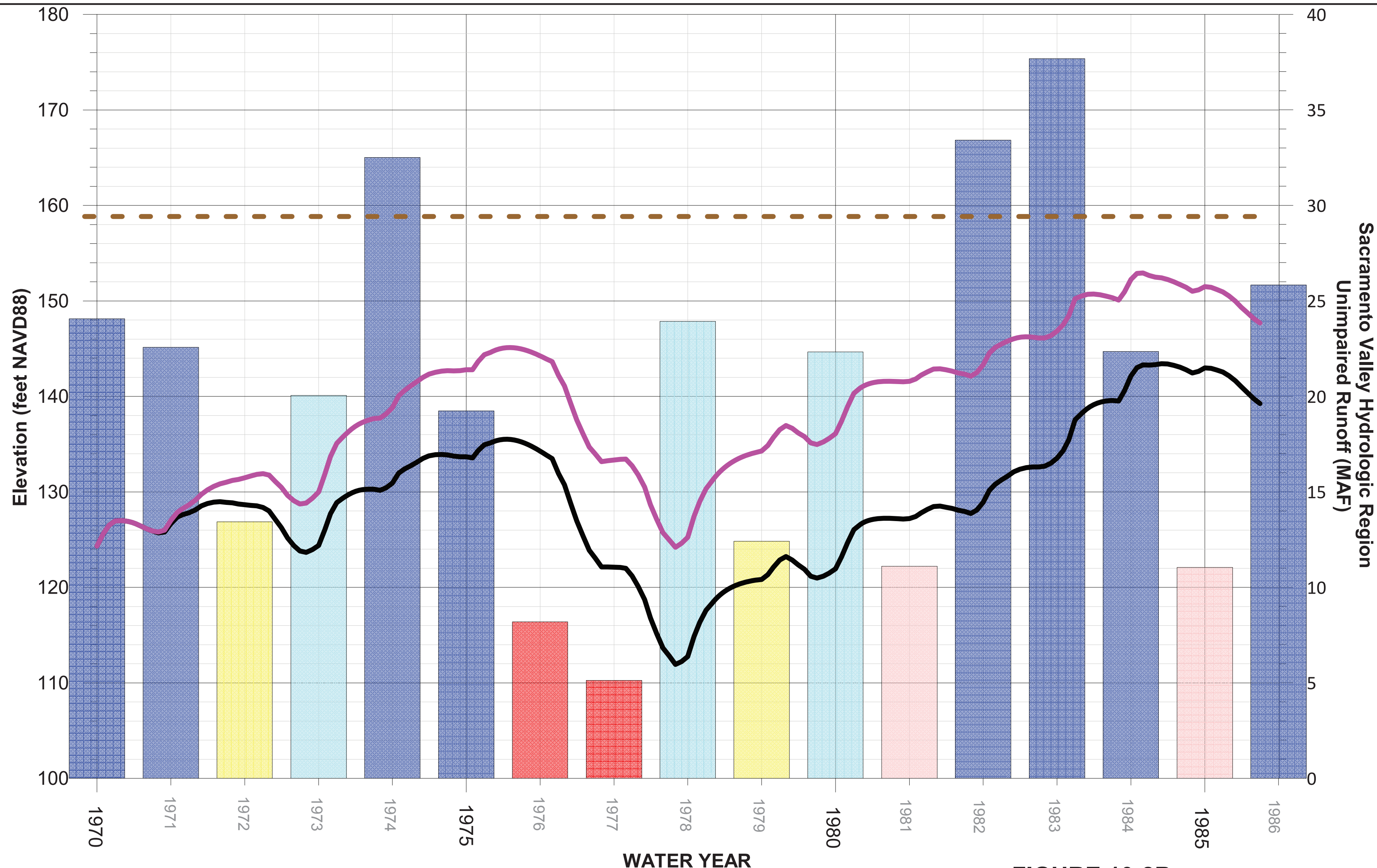
Further, the spring 2016 depths to water posted on Figures 10-9A and 10-9B suggest that the depths to water are larger than model forecast increase in groundwater levels (DWR, 2017a) where the data and contours coincide. Therefore, increases in groundwater levels resulting from reservoir seepage would represent a **beneficial impact** under almost all years as compared to the Existing Conditions/No Project/No Action Condition. In years with extremely wet climatic conditions, the addition of reservoir seepage to the groundwater system could slightly expand areas of shallow groundwater discharge to streams and topographic low areas; however, because this expansion would be limited in extent it would represent a **less-than-significant** impact when compared to the Existing Conditions/No Project/No Action Condition.



Notes:

1. Data Source: http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST
2. MAF = million acre-feet
3. NAVD88 = North American Vertical Datum of 1988

FIGURE 10-8A
Simulated Groundwater Elevations Versus Time near the SACFEM_{2013} Model Boundary
Sites Reservoir Project EIR/EIS



Notes:
1. Data Source: http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST
2. MAF = million acre-feet
3. NAVD88 = North American Vertical Datum of 1988

FIGURE 10-8B
Simulated Groundwater Elevations Versus Time at the Orchards Southeast of Funks Creek
Sites Reservoir Project EIR/EIS

SL0118171100RDD SPJPA_Fig10-8B_174_V1.ai dash 03/30/17

10.3.6 Impacts Associated with Alternative C

10.3.6.1 Extended Study Area – Alternative C

Construction, Operation, and Maintenance Impacts

Although there will be slight changes to the CVP and SWP water supplies (Tables 6-5 and 6-6) and San Luis Reservoir end-of-month storage (Section 6.3.3.1), the impacts associated with Alternative C, as they relate to groundwater supplies, decreases in groundwater levels (**Impact GW Res-1**), and increases in groundwater levels (**Impact GW Res-2**) would be the same as those described for Alternative A for the Extended Study Area.

10.3.6.2 Secondary Study Area – Alternative C

Construction, Operation, and Maintenance Impacts

The majority of the impacts associated with Alternative C, as they relate to groundwater supplies, decreases in groundwater levels (**Impact GW Res-1**), and increases in groundwater levels (**Impact GW Res-2**) would be the same as those described for Alternative A for the Secondary Study Area. The exception is the difference in operations of the SWP and CVP facilities between Alternatives A and C.

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

The potential impact of Project diversions under Alternative C at the Red Bluff Pumping Plant and GCID Main Canal intakes, and Delevan Pipeline Intake/Discharge Facilities on groundwater/surface water interaction and groundwater levels as compared to the Existing Conditions/No Project/No Action Condition were evaluated. Due to the fact that the reservoir size and surface water diversions under Alternative C are identical (in the case of reservoir size) or very similar (in the case of diversion rates), and that the impacts of Alternative B were deemed less than significant as discussed above, the impacts of surface water diversions under Alternative C on surface water/groundwater interaction compared to the Existing Conditions/No Project/No Action Condition are also deemed **less than significant**.

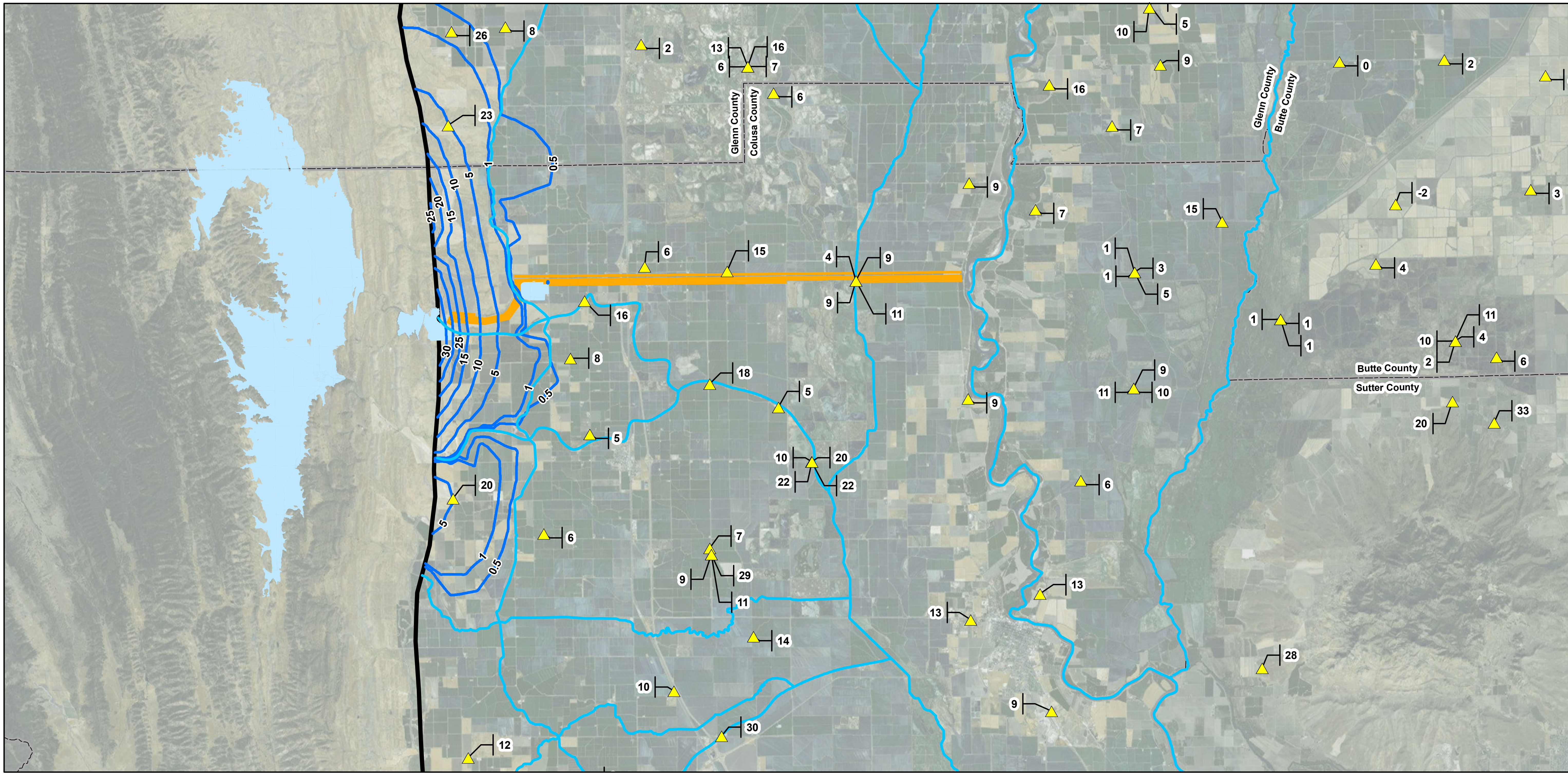
Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion.

10.3.6.3 Primary Study Area – Alternative C

Construction, Operation, and Maintenance Impacts

The majority of the Project facilities would be the same for Alternatives A, B, and C (see Chapter 3 Description of the Sites Reservoir Project Alternatives, Table 3-1). These facilities would require the same construction methods and operation and maintenance activities and would, therefore, result in the same construction, operation, and maintenance impacts on groundwater resources.



Legend

- Spring 2016 Depth to Groundwater (feet bgs)
- SACFEM2013 Stream
- Simulated Change in Groundwater Level (feet)
- SACFEM2013 Model Boundary
- County Boundary

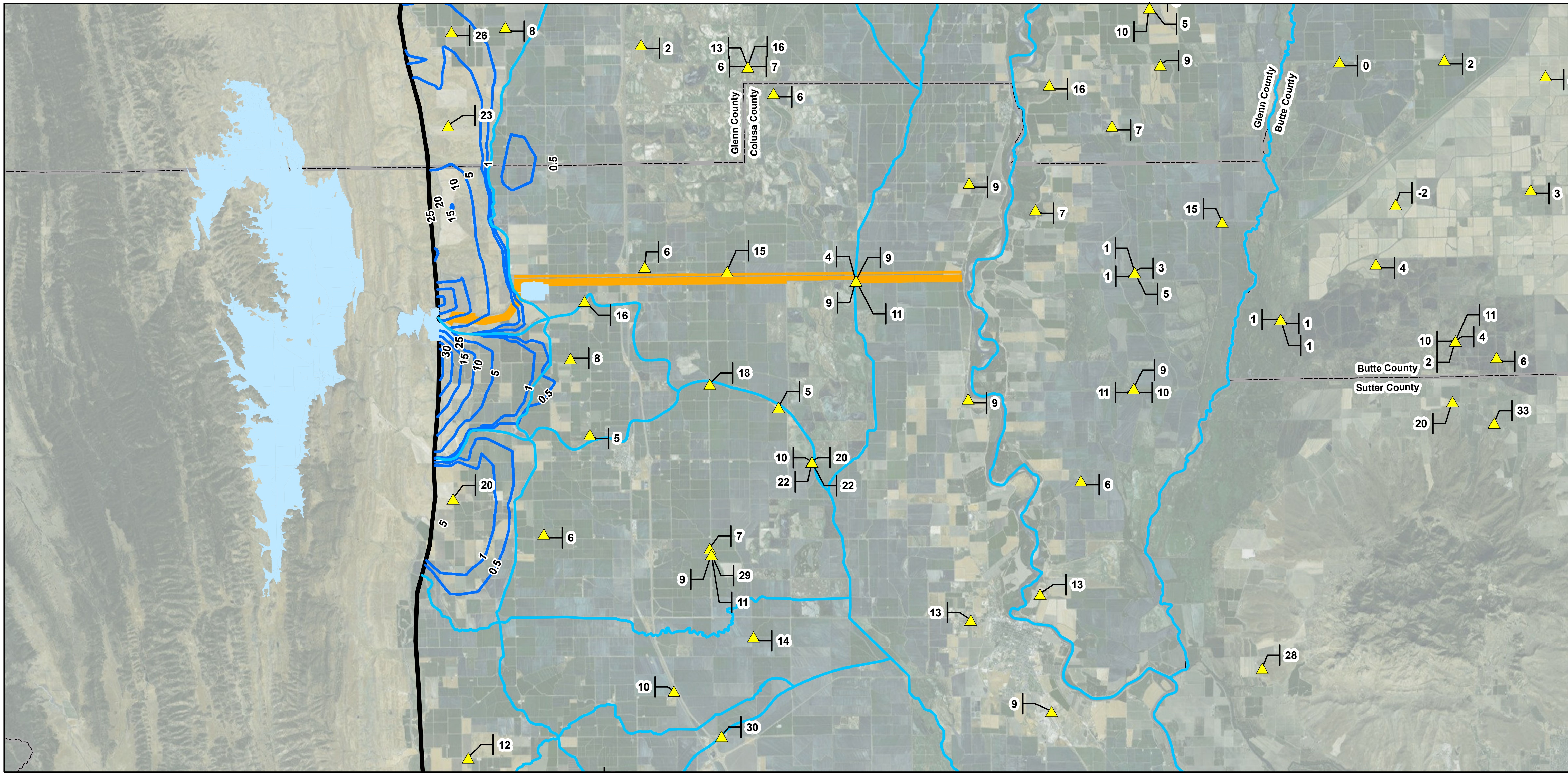
Select Project Features (Locations Approximate)

- Pipeline Construction Disturbance Area
- Reservoir

0 1.25 2.5 5
Miles

Notes:
1. Groundwater Subbasin Boundary and Spring 2016 Depth to Groundwater Source: https://gis.water.ca.gov/app/gicima/
2. bgs = below ground surface
3. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 10-9A
Simulated Increase in Groundwater Level Due to Seepage from Sites and Holthouse Reservoirs, Alternative B Shallow Aquifer, February 1980
Sites Reservoir Project EIR/EIS



Legend

- Spring 2016 Depth to Groundwater (feet bgs)
- SACFEM2013 Stream
- Simulated Change in Groundwater Level (feet)
- SACFEM2013 Model Boundary
- County Boundary

Select Project Features (Locations Approximate)

- Pipeline Construction Disturbance Area
- Reservoir

0 1.25 2.5 5
Miles

Notes:
1. Groundwater Subbasin Boundary and Spring 2016 Depth to Groundwater Source: https://gis.water.ca.gov/app/gicima/
2. bgs = below ground surface
3. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 10-9B
Simulated Increase in Groundwater Level Due to Seepage from Sites and Holthouse Reservoirs, Alternative B Shallow Aquifer, April 1983
Sites Reservoir Project EIR/EIS

The Alternative C design of the Sites/Delevan Overhead Power Line and Delevan Pipeline Intake/Discharge Facilities is the same as described for Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts on groundwater supplies, decreases in groundwater levels (**Impact GW Res-1**), and increases in groundwater levels (**Impact GW Res-2**) as those described for Alternative A.

The Alternative C design of the Sites Reservoir Inundation Area and Dams, Recreation Areas, and Road Relocations and South Bridge is the same as described for Alternative B. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts on groundwater supplies, decreases in groundwater levels (**Impact GW Res-1**), and increases in groundwater levels (**Impact GW Res-2**) as those described for Alternative B.

The boundary of the Project Buffer would be the same for all alternatives, but because the footprints of some of the Project facilities that are included in the Project Buffer would differ between the alternatives, the acreage of land within the Project Buffer would also differ. However, these differences in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. They would, therefore, have the same impact on groundwater supplies and recharge (**Impact GW Res-1**) and groundwater levels (**Impact GW Res-2**) as those described for Alternative A.

10.3.7 Impacts Associated with Alternative D

10.3.7.1 Extended Study Area – Alternative D

Construction, Operation, and Maintenance Impacts

Although there will be slight changes to the CVP and SWP water supplies (Tables 6-5 and 6-68) and San Luis Reservoir end-of-month storage (Section 6.3.3.1), the impacts associated with Alternative D as they relate to groundwater supplies, decreases in groundwater levels (**Impact GW Res-1**), and increases in groundwater levels (**Impact GW Res-2**) would be the same as those described for Alternative A for the Extended Study Area.

10.3.7.2 Secondary Study Area – Alternative D

Construction, Operation, and Maintenance Impacts

The majority of the impacts associated with Alternative D, as they relate to groundwater supplies, decreases in groundwater levels (**Impact GW Res-1**), and increases in groundwater levels (**Impact GW Res-2**) would be the same as those described for Alternative A for the Secondary Study Area. The exception is the difference in operations of the SWP and CVP facilities between Alternatives A and D.

Impact GW Res-1: Substantial Depletion of Groundwater Supplies or Substantial Interference with Groundwater Recharge Resulting in a Net Deficit in Aquifer Volume or a Lowering of the Local Groundwater Table Level, Causing Effects on Existing Land Uses or Planned Uses

The potential impact of Project diversions under Alternative D at the Red Bluff Pumping Plant and GCID Main Canal intakes, and Delevan Pipeline Intake/Discharge Facilities on groundwater/surface water interaction and groundwater levels as compared to the Existing Conditions/No Project/No Action

Condition were evaluated. Due to the fact that the reservoir size and surface water diversions under Alternative D are identical (in the case of reservoir size) or very similar (in the case of diversion rates), and that the impacts of Alternative B were deemed less than significant as discussed above, the impacts of surface water diversions under Alternative D on surface water/groundwater interaction compared to the Existing Conditions/No Project/No Action Condition are also deemed **less than significant**.

Impact GW Res-2: Increases in Groundwater Levels Resulting in Adverse Effects on Environmental Conditions and/or Existing Land Uses or Planned Uses

Refer to the **Impact GW Res-1** discussion.

10.3.7.3 Primary Study Area – Alternative D

Construction, Operation, and Maintenance Impacts

The majority of the Project facilities would be the same for Alternatives A, B, C, and D (see Chapter 3 Description of the Sites Reservoir Project Alternatives, Table 3-1). These facilities would require the same construction methods and operation and maintenance activities and would, therefore, result in the same construction, operation, and maintenance impacts on groundwater resources.

Therefore, unless explicitly discussed below, Alternative D facilities would have the same impacts that are described for Alternative A as they relate to groundwater supplies, decreases in groundwater levels (**Impact GW Res-1**), and increases in groundwater levels (**Impact GW Res-2**). The following are Project facilities and impacts associated with Alternative D:

- Alternative D would include the development of only two recreation areas (Stone Corral Recreation Area and Peninsula Hills Recreation Area) instead of up to five recreations areas that could be developed for each of the other alternatives. Alternative D would include a boat ramp on the western side of the reservoir where the existing Sites Lodoga Road would be inundated. Only two recreation areas under Alternative D is not expected to substantially change the potential impacts to groundwater supplies or result in changes to groundwater levels as compared to Alternative A.
- Under Alternative D, the TRR would be slightly smaller (approximately 80 acres smaller for Alternative D); however, the smaller TRR is not expected to change the potential impacts related to groundwater supplies or result in changes to groundwater levels as compared to Alternative A.
- For Alternative D, the Delevan Pipeline alignment would be approximately 50 to 150 feet south of the alignment presented under Alternatives A, B, and C. The Alternative D alignment takes advantage of existing easements to reduce impacts on local landowners. The shift in alignment is not expected to change the potential impacts to groundwater supplies or result in changes to groundwater levels.
- The boundary of the Project Buffer would be the same for all alternatives, but because the footprints of some of the Project facilities included in the Project Buffer would differ among the alternatives, the acreage of land within the Project Buffer would also differ. However, these differences in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities; therefore, Alternative D would have impacts similar to those described for all other alternatives.
- Alternative D includes a north-south alignment of the Delevan Overhead Power Line, rather than the east-west alignment between the TRR and the Delevan Pipeline Intake/Discharge Facility.

Additionally, Alternative D includes a proposed electrical substation west of Colusa in addition to the substation near the Holthouse Reservoir. The Alternative D north-south alignment of the Delevan Overhead Power Line and related substation are not anticipated to result in different impacts on groundwater levels than those described for the east-west line alignment for the other alternatives. The north-south alignment would be approximately 1 mile longer; however, it would be in or near an existing transportation and utility corridor for SR 45 and would not change the potential impacts related to groundwater supplies or result in changes to groundwater levels.

- Under Alternative D, the Lurline Headwaters Recreation Area would not be constructed; therefore, the road segment providing access to that recreation area would not be required. Alternative D includes an additional 5.2 miles of roadway from Huffmaster Road to Leesville Road; otherwise, the design of the Sites Reservoir Inundation Area and Dams, and South Bridge would be the same as that under Alternative A and is not expected to change the potential impacts related to groundwater supplies or result in changes to groundwater levels.

10.4 Mitigation Measures

Because no potentially significant impacts were identified, no mitigation is required or recommended. Environmental commitments, including provision of water supplies in the unlikely event of dewatering impacts are included in all Project alternatives and discussed in Chapter 3 Description of the Sites Reservoir Project Alternatives.

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