Chapter 7
Groundwater

7.1 Environmental Setting/Affected Environment

This section provides a description of the environmental setting/affected environment (as of 2009 NOP/NOI release date) related to groundwater resources that may be influenced by implementation of the Bay Delta Conservation Plan (BDCP) alternatives.

Groundwater provides about 35% of the state's water needs, and 40% or more during droughts. (California Department of Water Resources 2009a). With the growing limitations on available surface water exported through the Delta, and the potential impacts of climate change, reliance on groundwater through conjunctive management would become increasingly more important in meeting the state's future water uses.

For the purposes of this analysis, the groundwater study area (the area in which impacts may occur) specifically consists of the Delta Region, which also includes the Plan Area (the area covered by the BDCP) shown in Figure 7-1, the Upstream of the Delta Region, and the State Water Project (SWP) and Central Valley Project (CVP) Export Service Areas (Export Service Areas) Region. Groundwater supply impacts are directly linked to potential changes in surface water supply availability, which are discussed in Chapter 5, *Water Supply*.

7.1.1 Potential Environmental Effects Area

The Delta, Suisun Marsh, and the Central Valley overlie parts of several extensive groundwater basins that play key roles in local and regional water supply. The groundwater basins are influenced to various degrees by complex physical relationships in the affected areas.

- Rivers draining the Coast Ranges and the Sierra Nevada convey water into the Central Valley and Suisun Marsh, interconnect with the underlying groundwater basins, and eventually flow into San Francisco Bay. The Sacramento River Hydrologic Region overlies the Sacramento Valley groundwater basin. The San Joaquin River and Tulare Lake hydrologic regions overlie the San Joaquin Valley groundwater basin, and the San Francisco Bay Hydrologic Region (including the Suisun Marsh) overlies the Suisun-Fairfield Valley groundwater basin.
- Water is supplied to the Delta communities of Clarksburg, Courtland, Freeport, Hood, Isleton, Rio Vista, Ryde, and Walnut Grove by groundwater, and the largely agricultural San Joaquin Valley is dependent on groundwater to support agricultural and municipal demands (see Chapter 6, *Surface Water*).
- Some water flowing through the Delta is exported by the SWP/CVP to areas outside the Delta (see Chapter 5, *Water Supply*), and the availability of these water supplies influences the groundwater use and conditions of those areas. Groundwater basins in the Export Service Areas underlie several hydrologic regions in central and southern California, including parts of the San Joaquin, San Francisco Bay, Tulare Lake, Central Coast, Southern California, and Colorado River hydrologic regions.

- Throughout the potential effects area, geologic history and conditions strongly influence groundwater flow and aquifer recharge.
- Subsidence, such as peat soil compaction, can result from several mechanisms related to hydrogeologic conditions.

The existing groundwater conditions in the Delta Region, the Suisun Marsh, the Upstream of the Delta Region, and the SWP/CVP Export Service Areas are described to support discussions of environmental consequences (Section 7.3, *Environmental Consequences*) associated with potential changes resulting from the construction of project water conveyance and related facilities and implementation of CM2–CM22 in the Delta Region, as well as other indirect effects on groundwater resources stemming from the long-term operations and existence of these facilities and restored areas.

7.1.1.1 Central Valley Regional Groundwater Setting

The California Department of Water Resources (DWR) has delineated 515 distinct groundwater systems as described in Bulletin 118-03 (California Department of Water Resources 2003). These basins and subbasins have various degrees of supply reliability considering yield, storage capacity, and water quality. Figure 7-1 shows the statewide occurrence of groundwater and overlying Hydrologic Regions. The Delta overlies subbasins from both the Sacramento Valley and San Joaquin Valley Groundwater Basins and Suisun Marsh overlies the Suisun-Fairfield Valley Groundwater Basin. Outside the Delta and Suisun Marsh, to the north, the Sacramento River watershed overlies the Sacramento Valley Groundwater Basin. To the south, the San Joaquin River watershed overlies the San Joaquin Valley Basin.

The large and diverse Sacramento Valley and San Joaquin Valley groundwater basins have been divided into groundwater subbasins based primarily on surface water features, political boundaries, or both. The individual groundwater subbasins are not hydraulically distinct, have a high degree of interconnection, and tend to behave as single extensive alluvial aquifer systems. (California Department of Water Resources 2003).

The Sacramento Valley groundwater basin extends from the Red Bluff Arch south to the Cosumnes River. The Red Bluff Arch is near the northern end of the Central Valley and separates the Sacramento Valley groundwater basin from the Redding Area groundwater basin. The southern portion of the Sacramento Valley groundwater basin underlies the northern portion of the Delta. The Sacramento Valley groundwater basin is extremely productive and provides much of the water supply for California’s agricultural and urban water needs.

The San Joaquin Valley Groundwater Basin underlies the entire San Joaquin Valley from the south at the Tehachapi Mountains to the north with its boundary with the Sacramento Valley, where the basin’s northern portion underlies the southern half of the Delta. Two hydrologic regions occur in the San Joaquin Valley groundwater basin: the San Joaquin River and the Tulare Lake. Overall, the groundwater basin is continuous, but the surface water regime affects local groundwater conditions. The agricultural area of San Joaquin Valley is dependent upon groundwater to support agricultural and municipal demands. According to DWR estimates, slightly more than half of all groundwater use in the state occurs in the San Joaquin Valley groundwater basin (California Department of Water Resources 2003).

Outside the Delta watershed, other areas that receive surface water from the Delta watershed include the Central Coast Hydrologic Region and portions of Southern California, which have more hydraulically distinct groundwater basins than the Central Valley.

Regional Hydrogeology Overview

The geologic history of the Central Valley is summarized in Chapter 9, *Geology and Seismicity*. The occurrence and movement of potable groundwater within the groundwater basins underlying the Central Valley is discussed below and is based on findings from the U.S. Geological Survey (1986), except where noted.

Deposition of sediments from the Sierra Nevada and Coast Ranges into and along the margins of the shallow inland sea that once existed in the Central Valley was succeeded by continental deposition. Sediment transport from the surrounding uplands into the Central Valley resulted in aquifers with hydraulic characteristics that vary north to south and east to west. North-to-south variability occurs because sediment transport from the surrounding uplands was controlled by local drainage. East-to-west variability resulted from the different types of exposed bedrock, reworked sediments, and volcaniclastic input (rocks composed of volcanic material that has been transported and reworked by wind and water) between the Coast Ranges to the west and the Sierra Nevada to the east. Hydrogeologic characteristics are discussed in more detail in the sections that follow.

Groundwater-Surface Water Interaction

Rivers play a large role in the hydrogeology of the Central Valley by bringing water from the uplands during the snowpack's spring melt and providing recharge to the underlying aquifers. In areas of shallow groundwater table, rivers also can receive groundwater inflow. The quantity and timing of snowpack melt are the predominant factors affecting surface water and groundwater, and peak runoff typically follows peak precipitation by one to two months (U.S. Geological Survey 1991). Rivers drain the Coast Ranges and the Sierra Nevada, bringing the water into the valley and converging with the Sacramento and San Joaquin Rivers aligned along the axes of their respective valleys (see Chapter 6, *Surface Water*). The drainage in each valley has a key difference; in the San Joaquin Valley, fewer major rivers drain the Coast Ranges, whereas the Sacramento Valley has several, including Stony, Cache, Putah, and numerous other west side tributary creeks that flow to the Sacramento River.

In the Sacramento Valley groundwater basin, the interaction between surface water and groundwater systems is highly variable spatially and temporally. Generally, the major trunk streams of the valley (the Sacramento and Feather Rivers) tend to act as drains and receive groundwater discharge throughout most of the year. The exceptions are areas of depressed groundwater levels attributable to groundwater pumping, where the water table has been artificially lowered, inducing leakage from the rivers that recharge the groundwater system. In contrast, the tributary streams draining into the Sacramento River from upland areas are almost all *losing* streams (water from the streams enters and recharges the groundwater system) in their upper reaches, but some transition to *gaining* streams (water from the groundwater enters the streams) farther downstream closer to their confluences with the Sacramento River. Groundwater modeling studies of the Sacramento Valley suggest that, on average, the flux of groundwater discharging to the rivers is approximately equal to the quantity of water that leaks from streams to recharge the aquifer system. The studies suggest that in average years, stream recharge and aquifer recharge are each about 800,000 AF per year (Glenn Colusa Irrigation District and the Natural Heritage Institute 2010).

In the San Joaquin Valley groundwater basin, the interaction between the surface water and groundwater systems is substantially different. Long-term groundwater production throughout this basin has lowered groundwater levels beyond what natural recharge can replenish. Most streams leak to the underlying aquifers and recharge the aquifer system. For example, along much of the San Joaquin River, the river is a losing river and groundwater is recharged by leakage from the river. This is especially true in the Gravelly Ford area of the San Joaquin River (upstream of Mendota Pool), where the riverbed is highly permeable and river water readily seeps into the underlying aquifer. In the northern portions of the San Joaquin River, groundwater levels are shallow and groundwater discharges into the river.

Historically, rivers have defined the boundaries for most groundwater subbasins in the Sacramento and San Joaquin Valleys. However, in almost all cases, these rivers do not act as hydraulic barriers or groundwater divides. An example is Putah Creek, which delineates the boundary between the Sacramento Valley groundwater basin's Yolo and Solano Subbasins. As Putah Creek flows eastward through Solano and Yolo counties toward the Sacramento River, numerous diversions along its course reduce streamflow to minimal levels by the time it reaches the Sacramento River. As the creek passes through the Yolo Bypass, which has no well-defined channel, the potential for the creek to act as a hydraulic barrier between the subbasins is further reduced. Although the groundwater system in the Yolo Bypass has not been well studied, it is likely that it functions as a single alluvial aquifer rather than the two discrete aquifers as the official subbasin (Yolo and Solano) designations suggest.

The major regional aquifers that make up the Sacramento Valley and San Joaquin Valley groundwater basins are regionally extensive aquifer systems. These aquifer systems act as large interconnected alluvial aquifers that may be subdivided vertically, but are not isolated local-scale aquifer systems as one might infer from the subbasin terminology.

Regional Groundwater Use Overview

The importance of groundwater as a resource varies regionally. The Central Coast Hydrologic Region has the most reliance on groundwater to meet its local uses, with more than 80% of its water use supplied by groundwater in an average year. The Tulare Lake Hydrologic Region meets about 50% of its local uses with groundwater extraction. The rest of the Central Valley meets between 15 and 35% of local uses with groundwater. In Southern California, the use of groundwater varies between 15% to 35% of annual use (South Coast Hydrologic Region) and 70% of annual use (South Lahontan Hydrologic Region). In general, of all the groundwater extracted annually in the state in an average year, more than 35% is produced in the Tulare Hydrologic Region, and more than 70% occurs in the Central Valley (California Department of Water Resources 2009a:8–10).

7.1.1.2 Delta and Suisun Marsh Groundwater Setting

The Delta overlies the western portion of the area where the Sacramento Valley and San Joaquin Valley groundwater basins converge. Underlying the northern Delta within the Sacramento Valley groundwater basin are the Solano Subbasin in the northwest and the South American Subbasin to the northeast bounded by the Sacramento and the Cosumnes rivers. Within the San Joaquin Valley groundwater basin, the Tracy Subbasin underlies the southern half of the Delta and the Eastern San Joaquin and Cosumnes Subbasins underlie the central and eastern Delta (Figure 7-2). The Suisun Marsh overlies the Suisun–Fairfield Valley groundwater basin, which is adjacent to but hydrogeologically distinct from the Sacramento Valley groundwater basin, and is adjacent to the San Francisco Bay. This basin is bounded by the Coast Ranges to the north and west and the

Sacramento Valley groundwater basin in the east. It is separated from the Sacramento Valley groundwater basin by the English Hills.

Physical and hydrogeologic characterizations of each major groundwater basin underlying the Delta and Suisun Marsh are presented within DWR Bulletin 118 (California Department of Water Resources 2003), various USGS reports (U.S. Geological Survey 1960, 2006b, 2008), and other available literature as cited throughout this section. The only comprehensive review of groundwater conditions in the Suisun-Fairfield Valley groundwater basin was completed in 1960 (U.S. Geological Survey 1960). More current groundwater information has been collected for numerous site-specific projects, such as Travis Air Force Base (AFB), the Solano County Landfill Company/Potrero Hills Landfill site, and the recent USGS Groundwater Ambient Monitoring and Assessment Program (GAMA) (U.S. Geological Survey 2008), but this information is limited in areal extent.

Groundwater Basin Hydrogeology

In general, shallow groundwater conditions and extensive groundwater–surface water interaction characterize the Delta and Suisun Marsh area. Spring runoff generated by melting snow in the Sierra Nevada increases flows in the Sacramento and San Joaquin rivers and tributaries and causes groundwater levels near the rivers to rise. Because the Delta is a large floodplain and the shallow groundwater is hydraulically connected to the surface water, changes in river stages affect groundwater levels and vice versa. This hydraulic connection is also evident when the tide is high and surface water flows from the ocean into the Delta, thereby increasing groundwater levels nearby.

Groundwater levels in the central Delta are very shallow, and land subsidence on several islands has resulted in groundwater levels close to the ground surface. Maintaining groundwater levels below crop rooting zones is critical for successful agriculture, especially for islands that lie below sea level, and many farmers rely on an intricate network of drainage ditches and pumps to maintain groundwater levels of about 3 to 6 feet below ground surface. The accumulated agricultural drainage is pumped through or over the levees and discharged into adjoining streams and canals (U.S. Geological Survey 2000a). Without this drainage system, the islands would become flooded.

Delta floodplain deposits contain a significant percentage of organic material (peat) ranging in thickness from 0–150 feet. Below the surficial deposits, unconsolidated non-marine sediments occur, above the fresh/saline water boundary at depths as shallow as a few hundred feet near the Coast Range to nearly 3,000 feet near the eastern margin of the basin. These non-marine sediments form the major water-bearing formations in the Delta.

In the Suisun-Fairfield Valley basin, freshwater occurs within the alluvium and Sonoma volcanics. Alluvium can be up to 260 feet thick in the western portion of the basin and uncomfortably overlies the volcanics (U.S. Geological Survey 1960). Alluvium near Travis AFB can be up to 70 feet thick, according to information collected during groundwater investigations at the base (Travis Air Force Base 1997).

Table 7-1 lists key Sacramento Valley Subbasin aquifers near the Delta and Suisun Marsh (the Solano, Yolo, and South American Subbasins) and summarizes their general hydrogeologic characteristics. Three subbasins within the San Joaquin Valley Groundwater Basin—Cosumnes, Eastern San Joaquin, and Tracy—underlie the Delta. Key hydrologic characteristics of these three subbasins are summarized in Table 7-2.

Table 7-1. Freshwater Aquifers of the Southern Sacramento Valley Groundwater Basin

	Subbasin Occurrence[a]							
Aquifer Name	South American	Solano	Yolo	Aquifer Age	Thickness (feet)	Estimated Yield[b] (gpm)	General Description	Comments
Younger Alluvium	X	X	X	Recent	0–150	Low to moderate, if saturated	Flood basin (with peat in the Delta), dredge tailing (South American Subbasin), and stream channel deposits	Poor water quality
Older Alluvium (undifferentiated)		X	X	Pliocene to Pleistocene	60–130	Generally 300–1,000, up to 4,000 adjacent to the Sacramento River, and 50–150 in finer-grained portions of the aquifer	Alluvial fan deposits	
Older Alluvium (differentiated)[c]	X			Pliocene to Pleistocene	100–650		Alluvial fan deposits	
Mehrten Formation	X			Miocene to Pliocene	200–1,200		Reworked volcaniclastics (permeable) and dense tuff breccia (confining units)	
Tehama Formation		X	X	Pliocene	1,500–2,500	Several thousand	Lithic-arkosic fluvial sediments; bioturbated sandstone and mudstone	Base of freshwater

Sources: California Department of Water Resources 2009b; Smith 1987

Note: gpm = gallon(s) per minute

[a] Only subbasins within the Delta or Yolo Bypass are included.

[b] No value indicates that the California Department of Water Resources has not estimated subbasin yield.

[c] Differentiated units are the Modesto, Riverbank, Victor, Laguna, and Fair Oaks formations and the Arroyo Seco and South Fork gravels.

Table 7-2. Freshwater Aquifers of the Northern San Joaquin Valley Groundwater Basin

	Subbasin Occurrence[a]							
Aquifer Name	Cosumnes	Eastern San Joaquin	Tracy	Aquifer Age	Thickness (feet)	Estimated Yield[b] (gpm)	General Description	Comments
Younger Alluvium	X		X	Recent	0–100	Can yield significant water	Dredge tailing and stream channel deposits	
Older Alluvium (undifferentiated)			X	Pliocene to Pleistocene	150		Alluvial fan deposits	
Older Alluvium (differentiated)[c]	X			Pliocene to Pleistocene	100–650		Alluvial fan deposits	
Alluvium and Modesto/Riverbank formations		X		Recent to Late Pleistocene	0–150	650+	Alluvial and interfan deposits	
Flood basin deposits (undifferentiated)		X	X	Recent to Pliocene	0–1,400	low	Flood basin deposits	Generally poor water quality with occasional areas of fresh water. Basinward (finer grained) lateral equivalents of the Tulare, Laguna, Riverbank, Modesto, and Recent formations occur within the Delta.
Laguna Formation		X		Pliocene to Pleistocene	400–1,000	Average of 900, but up to 1,500	Fluvial	
Mehrten Formation	X	X		Miocene to Pliocene	200–1,200		Reworked volcaniclastics (permeable) and dense tuff breccia (confining units)	
Tulare Formation			X		1,400	Up to 3,000	Clay, silt and gravel	Poor water quality above the Corcoran Clay, which occurs near the top of the formation.

Source: California Department of Water Resources 2009b

Note: gpm = gallon(s) per minute

[a] Only subbasins within the Delta or Yolo Bypass are included.

[b] No value indicates that the California Department of Water Resources has not estimated subbasin yield.

[c] Differentiated units are the Modesto, Riverbank, Victor, Laguna, and Fair Oaks formations and Arroyo Seco and South Fork gravels.

Groundwater in the South American and Eastern San Joaquin Subbasins generally flows from the Sierra Nevada on the east toward the low-lying lands of the Delta to the west. However, a number of pumping areas have reversed this trend, and groundwater inflow from the Delta toward these pumping areas has been observed, primarily in the Stockton area.

Groundwater levels in the South American Subbasin have fluctuated over the past 40 years, with the lowest levels occurring during periods of drought. From 1987 to 1995, water levels declined by about 10 to 15 feet and then recovered by the same amount until 2000, to levels close to the mid-eighties. Areas affected by municipal pumping show a lower groundwater level recovery than other areas (California Department of Water Resources 2004a:2). Groundwater levels in the East San Joaquin Subbasin have continuously declined in the past 40 years due to groundwater pumping. Cones of depression are present near major pumping centers such as Stockton and Lodi (California Department of Water Resources 2006a:2). Groundwater level declines of up to 100 feet have been observed in some wells.

In the Solano Subbasin, historical general groundwater flow direction is from northwest to southeast (California Department of Water Resources 2004b:1). Increasing agricultural and urban development in the 1940s in the Solano Subbasin has caused groundwater level declines. Today, groundwater levels are mostly affected by drought cycles but tend to recover quickly during wet years (California Department of Water Resources 2004b:2).

In the Tracy Subbasin, groundwater generally flows south to north and discharges into the San Joaquin River. According to DWR and the San Joaquin County Flood Control and Water Conservation District, groundwater levels in the Tracy Subbasin have been relatively stable over the past 10 years, apart from seasonal variations resulting from recharge and pumping (California Department of Water Resources 2006b:2).

Underlying the Suisun Marsh, the overall direction of groundwater flow in the Suisun-Fairfield Valley groundwater basin is from the uplands toward Suisun Marsh (U.S. Geological Survey 1960). It is assumed that the cone of depression present in 1950 no longer exists because Fairfield now obtains its water supply from surface water, but no current, comprehensive basinwide assessment of groundwater levels is readily available. Depth to groundwater varies seasonally, with higher groundwater levels occurring during the rainy season (Travis Air Force Base 1997). Few groundwater monitoring sites exist in the basin, and most are near ongoing groundwater investigations. Data from these groundwater investigations suggest that groundwater levels in the basin are generally stable.

Municipal and irrigation wells are typically screened deeper in the aquifer (200–400 feet below ground surface [bgs]) than the domestic wells in the basin (100–250 feet bgs). Table 7-3 summarizes available information about the depths of the various well types in the Delta.

Table 7-3. Delta and Suisun Marsh Groundwater Basin and Subbasin Wells Summary[a,b]

		Domestic Wells			Municipal and Irrigation Wells			Well Yield (gpm)		Number of Monitoring Wells		
Basin/ Subbasin Name[c]	Area (acres)	No.[d]	Depth Range (feet bgs)	Depth Average (feet bgs)	No.[d]	Depth Range (feet bgs)	Depth Average (feet bgs)	Range	Average	Levels	Quality	Title 22
Sacramento Valley Groundwater Basin												
South American (2/27/04)	248,000	422	87–575	247	78	41–1,000	372	—	(Municipal Use) 908 (Industrial Use) 971	105	9	247
Solano (2/27/04)	425,000	—	38–1,070	239	—	62–2,275	510	—	—	123	23	136
Yolo (2/27/04)	256,000	—	40–600	243	—	50–1,500	400	150–4,000+	1,500	127	133	—
San Joaquin Valley Groundwater Basin												
Cosumnes (2/03/06)	281,000	832	10–812	261	48	130–934	473	650–1,500	—	75	13	72
Eastern San Joaquin (1/20/06)	707,000	1,551	25–993	242	224	75–780	349	650–1,500	—	360	26	540
Tracy (1/20/06)	345,000	888	44–665	188	70	60–1,020	352	500–3,000	—	18	6	183

Source: California Department of Water Resources 2009b (Bulletin 118-03)

Notes: Title 22 refers to wells installed to monitor groundwater quality associated with groundwater recharge for indirect potable reuse.
bgs = below ground surface
gpm = gallon(s) per minute

[a] A basin summary for the Suisun-Fairfield Valley Groundwater Basin was not prepared by DWR for Bulletin 118.

[b] A dash indicates that the information was not summarized by DWR for Bulletin 118.

[c] Some subbasin descriptions have been revised since the release of Bulletin 118. The date in parentheses indicates the version used to prepare the table. The Suisun-Fairfield Valley Groundwater Basin was not included in the 2003 version of Bulletin 118.

[d] The number of wells is based on the number of logs used to estimate well depth. The number of wells of each type probably varies from the number indicated.

Groundwater Quality

A recent groundwater quality study was performed in the southern Sacramento Valley region in which more than 60 wells were sampled (U.S. Geological Survey 2008). As part of GAMA, two wells were sampled in the Delta areas. One is located in the central Delta west of Sherman Island and the Sacramento River and has a depth of 800 feet bgs. The other is located in the eastern Delta near the Delta Cross Channel and has a depth of 244 feet bgs. Both wells were sampled for several chemical constituents. Some of the results from this study are reported below, along with results from other studies and reports.

In the South American Subbasin, total dissolved solids(TDS) levels range from 24 to 581 mg/L, with an average of 221 mg/L based on 462 records (California Department of Water Resources 2004a:3). Seven sites present significant groundwater contamination in this basin, including three Superfund sites near the Sacramento metropolitan area. These sites are in various stages of cleanup.

TDS varies more widely in the Eastern San Joaquin Subbasin, ranging between 50 and 3,520 mg/L. The high salinity of groundwater is attributed to poor-quality groundwater intrusion from the Delta caused by the decline of groundwater levels. This saline groundwater front has been particularly apparent in the Stockton area since the 1970s (San Joaquin County Flood Control and Water Conservation District 2008). Ongoing studies are attempting to identify the source or sources of chloride in groundwater along a line extending from Manteca to the northern side of Stockton. Initial concern was that long-term overdraft conditions in the eastern portion of the subbasin were enabling more saline water from the Delta to migrate inland. Other possible sources include upward movement of deeper saline formation water and agricultural practices (U.S. Geological Survey 2006a).

High chloride concentrations have also been observed in well water in the Eastern San Joaquin Subbasin. The source of chloride concentrations of up to 1,800 mg/L near the Delta may be due to saline water intrusion from the Delta, but other sources are possible, such as high-chloride water moving upward from the deeper saline formations as a consequence of extensive groundwater pumping and agricultural return flows (U.S. Geological Survey 2006a). In addition, large areas of groundwater with elevated nitrate concentrations exist in several portions of the subbasin, such as southeast of Lodi and south of Stockton. The City of Lodi operates the White Slough Water Pollution Control Facility, a 6.3 million gallon per day (MGD) (average flow) plant on the eastern edge of the Delta on the western side of Interstate 5, approximately 1 mile south of Highway 12. Agricultural and stormwater runoff are returned to unlined holding ponds. Water quality concerns have been evaluated regarding elevated nitrates and salinity by the State Water Resources Control Board (City of Lodi 2006; Stockton Record Staff 2009).

Groundwater quality in the Solano Subbasin is generally good and is deemed appropriate for domestic and agricultural use (California Department of Water Resources 2004b:3). However, TDS concentrations at levels higher than 500 parts per million have been observed in the central and southern areas of the basin.

In the Tracy Subbasin, areas of poor water quality exist throughout. Elevated chloride concentrations are found along the western side of the subbasin near the City of Tracy and along the San Joaquin River. Overall, Delta groundwater wells in the Tracy Subbasin show levels above the secondary maximum contaminant level for chloride, TDS, arsenic, and boron (U.S. Geological Survey 2006b).

Groundwater quality issues within the Suisun-Fairfield Valley groundwater basin include boron, TDS, and volatile organic compound contamination present at Travis AFB. In a USGS study of water quality in the area, TDS concentrations were not measured directly, but were inferred from measured specific conductance values (U.S. Geological Survey 1960). The specific conductance is a measure of how well water can conduct an electric current. The specific conductance increases with increasing amount and mobility of dissolved solids in the water. Thus, the higher the TDS concentration (and salinity), the higher the specific conductance. Specific conductance was measured in more than 70 wells, yielding values ranging from 158 to 3,260 micromhos, with most values ranging from about 500 to 1,600 micromhos. These values are similar to those reported in the USGS GAMA Program study, with specific conductance values ranging from 859 to 1,300 microsiemens per centimeter (the current equivalent standard for measuring specific conductance, which is comparable to micromhos) in the five wells tested (U.S. Geological Survey 2008). The California secondary drinking water standard for specific conductance is recommended at 900 microsiemens per centimeter (taste and odor threshold) and the upper limit is set at 1,600 microsiemens per centimeter. The non-regulatory agricultural water quality goal is recommended at 700 micromhos per centimeter for the most salt-sensitive crops.

Volatile organic compound plumes at Travis AFB are largely contained on base, but volatile organic compound constituents have migrated up to 0.5 mile off base at three sites. Containment and remediation is occurring at each of these sites (Travis AFB 2005).

The only other major concern mentioned by existing water quality studies of the Suisun-Fairfield Valley groundwater basin is boron. USGS reported boron data for 62 wells ranging from non-detect to 28 mg/L, but only six detects were greater than 3 mg/L (U.S. Geological Survey 1960). The GAMA Program study data also indicated elevated boron concentrations (5.4 mg/L) for at least one well sample (U.S. Geological Survey 2008).

Groundwater Production and Use

Groundwater is used throughout the Delta through the mechanisms of pumping and plant uptake in the root zone. However, an accurate accounting of groundwater used in the region is not available because wells are not metered. In the upland peripheral Delta areas, average annual groundwater pumping is estimated to range between 100,000 and 150,000 acre-feet, both for domestic and agricultural uses (CALFED 2000:5.4-8). Although information on groundwater yield is limited in the Delta subbasins, available estimates in the northern San Joaquin Valley Groundwater Basin indicate that maximum well yield varies from around 1,500 to 3,000 gpm (Table 7-3).

The City of Stockton depends almost entirely on groundwater for its municipal and industrial water needs. Groundwater use in the Contra Costa Water District (CCWD) service area is approximately 3,000 acre-feet per year with another 500 acre-feet per year produced by the City of Pittsburg. Groundwater is produced at the CCWD's Mallard Wells and wells owned and operated by the City of Pittsburg, Golden State Water Company, and Diablo Water District. In addition, an undetermined number of privately held groundwater wells exist in the CCWD service area (CALFED 2005). Groundwater in this area is primarily produced from the Clayton basin, which has seen a gradual decline in groundwater elevation (Contra Costa Water District 2005).

Groundwater also provides water supply for the Delta communities of Clarksburg, Courtland, Freeport, Hood, Isleton, Rio Vista, Ryde, and Walnut Grove. In the rural portions of the Delta, private groundwater wells provide domestic water supply (Solano Agencies 2005). In the central Delta, groundwater use is limited because of low well yields and poor water quality. Shallow groundwater occurring at depths of less than 100 feet is too saline and therefore not adequate for most beneficial uses. Approximately 200 square miles of the central Delta are affected by saline shallow groundwater (CALFED 2000:5.4-7). Because shallow groundwater levels are detrimental when they encroach on crop root zones, groundwater pumping is used to drain the waterlogged agricultural fields. Groundwater pumping for agricultural irrigation mostly occurs in the north Delta for orchards and in the south Delta around the City of Tracy.

Information on groundwater supplies in the Suisun-Fairfield Valley basin is limited. Groundwater was the primary water source for the Suisun–Fairfield Valley groundwater basin, including the cities of Fairfield and Suisun City, through the 1950s. This groundwater production resulted in local areas of depressed groundwater levels. As surface water became available, groundwater use declined. Studies have shown that the basin provides low well yields and therefore is probably not used as a major water supply (Bureau of Reclamation et al. 2010:5.3-10). Many private well owners in the Suisun Marsh basin use groundwater for landscape irrigation. However, the poor quality of the Suisun Marsh basin groundwater prevents municipal use and potable water is typically imported (Bureau of Reclamation et al. 2010:5.3-10).

Land Subsidence

Subsidence in the Delta is well-documented and a major source of concern for farming operations. The oxidation of peat soils is the primary mechanism of subsidence in the Delta, and some areas are located below sea level (see Chapter 10, *Soils,* and Chapter 9, *Geology and Seismicity*). Subsidence in the Suisun-Fairfield Valley groundwater basin has not been extensively monitored.

7.1.1.3 Delta Watershed Groundwater Setting

The Delta watershed area includes the Upstream of the Delta Region and portions of the Export Service Areas in the Sacramento River and San Joaquin River regions and the Tulare Lake Region.

Sacramento River Region

North of the Delta, the Sacramento River Hydrologic Region overlies one of the largest groundwater basins in the state, the Sacramento Valley Groundwater Basin. DWR divides the Sacramento Valley basin into 17 subbasins (Figure 7-3) based on groundwater characteristics, surface water features, and political boundaries (California Department of Water Resources 2003). However, these individual groundwater subbasins have a high degree of hydraulic interconnection because the rivers—the primary method of defining the subbasin boundaries—do not act as barriers to groundwater flow. Therefore, the Sacramento Valley groundwater basin functions primarily as a single laterally extensive alluvial aquifer, rather than numerous discrete, smaller groundwater subbasins.

Groundwater Basin Hydrogeology

Freshwater in the Sacramento Valley groundwater basin occurs within the continental deposits, which are generally 2,000–3,000 feet thick. Hydrogeologic units containing freshwater along the eastern portion of the basin, primarily the Tuscan and Mehrten formations, are derived from the Sierra Nevada. Toward the southeastern portion of the Sacramento Valley, the Mehrten formation is overlain by sediments of the Laguna, Riverbank, and Modesto formations, which also originated in the Sierra Nevada. The primary hydrogeologic unit in the western portion of the Sacramento Valley groundwater basin is the Tehama formation, which was derived from the Coast Ranges. In most of the Sacramento Valley, these deeper units are overlain by younger alluvial and floodplain deposits.

The water budget (the components of inflow, outflow, and change in storage) of the Sacramento Valley groundwater basin is dominated by a great annual inflow of water falling as precipitation on the surrounding mountains and on the valley floor. A portion of this water is consumed through evapotranspiration by vegetation and surface evaporation, and most of the remainder becomes runoff and groundwater recharge. The annual total runoff to the Sacramento Valley Hydrologic Region is 22.4 million acre-feet (MAF), including 850,000 acre-feet estimated to recharge the Redding Groundwater Basin. Applied annual agricultural water irrigation totals approximately 7.7 MAF in the Sacramento Valley Groundwater Basin (California Department of Water Resources 1998). A portion of this applied water, and the remaining 13.9 MAF of runoff, is potentially available to recharge the basin and replenish groundwater storage depleted by groundwater pumping. Therefore, except during drought, the Sacramento Valley groundwater basin is “full,” and groundwater levels recover to pre-irrigation season levels each spring. Historical groundwater level hydrographs suggest that even after extended droughts, groundwater levels in this basin recovered to pre-drought levels within 1 or 2 years following the return of normal rainfall quantities.

Generally, groundwater flows inward from the edges of the basin toward the Sacramento River, then in a southerly direction parallel to the river. Depth to groundwater throughout most of the Sacramento Valley averages about 30 feet bgs, with shallower depths along the Sacramento River and greater depths along the basin margins.

As agricultural land use and water demands have intensified over time, groundwater levels in certain areas have declined because increases in pumping have not been matched by increases in recharge. This condition has been the motivating force for development of supplemental surface supplies in a number of locales during the past 30 to 40 years, including Yolo County with its construction of Indian Valley Dam on the North Fork of Cache Creek, South Sutter Water District with its construction of Camp Far West Reservoir on the Bear River, and Yuba County, which constructed New Bullards Bar Dam and Reservoir on the North Yuba River.

Today, groundwater levels are generally in balance valley-wide, with pumping matched by recharge from the various sources annually. Some locales show the early signs of persistent drawdown, including the northern Sacramento County area, areas near Chico, and on the far west side of the Sacramento Valley in Glenn County where water demands are met primarily, and in some locales exclusively, by groundwater. These could be early signs that the limits of sustainable groundwater use have been reached in these areas.

Groundwater Quality

Sacramento Valley Groundwater Basin groundwater quality is generally suitable for municipal, agricultural, domestic, and industrial uses. However, some localized groundwater quality problems exist. Natural groundwater quality is influenced by streamflow and recharge from the surrounding Coast Ranges and Sierra Nevada. Runoff from the Sierra Nevada is generally of higher quality than runoff from the Coast Ranges, where marine sediments affect water quality. Therefore, groundwater quality tends to be better in the eastern half of the Sacramento Valley. Groundwater quality also varies from north to south, with the better water quality occurring in the northern portion of the valley and poorer water quality in the southwestern portion (U.S. Geological Survey 1984).

In the southern half of the Valley, the TDS levels are higher because of upwelling of deep saline water; large areas have TDS concentrations exceeding 500 mg/L. TDS concentrations as high as 1,500 mg/L have been reported in a few areas (U.S. Geological Survey 1991). Areas that have high TDS concentrations include the south-central part of the Sacramento Valley Groundwater Basin, south of Sutter Buttes, in the area between the confluence of the Sacramento and Feather Rivers. The area west of the Sacramento River, between Putah Creek and the Delta, also has elevated TDS levels. The area around Maxwell, Williams, and Arbuckle has high concentrations of chloride, sodium, and sulfate (California Department of Water Resources 1978). TDS in this region averages about 500 mg/L, but concentrations exceeding 1,000 mg/L have been reported. The source of salinity in the Maxwell and Putah Creek areas is associated with mineral springs in the hills to the west. High salinity around the Sutter Buttes is believed to be caused by upwelling of saline water from underlying marine sediments (U.S. Geological Survey 1984).

Nitrates found in groundwater have various sources, including fertilizer use, wastewater disposal, and natural deposits. Concentrations of nitrate as N exceeding 10 mg/L (which is the maximum contaminant level [MCL]) are found throughout portions of the Central Valley; however, concentrations exceeding 30 mg/L as N are rare and localized. In the Sacramento Valley Groundwater Basin, the background nitrate concentration is estimated to be less than or equal to 3 mg/L. Two areas of elevated (greater than 5.5 mg/L) nitrate concentrations have been identified: one in northern Yuba and southern Butte counties (in the Gridley-Marysville area) and another in northern Butte and southern Tehama counties (in the Corning-Chico area). Approximately 25% to 33% of samples from these areas have concentrations exceeding the MCL of 10 mg/L. Elevated nitrate concentrations in these areas are associated with shallow wells, and are thought to be the result of a combination of fertilizers and septic systems.

Groundwater Production and Use

Wells developed in the sediments of the valley provide excellent supply to irrigation, municipal, and domestic uses. Many of the mountain valleys within the region also provide significant groundwater supplies to multiple uses.

Approximately 31% of the region’s urban and agricultural water needs are met by groundwater (California Department of Water Resources 2003:159). Although surface water supplies provide the majority of water used by the Sacramento Valley’s agricultural sector, groundwater provides approximately 10–15% of the total water used to support agricultural uses, depending on water year type. Municipal, industrial, and agricultural water demands in the region total approximately 8 MAF, and groundwater provides about 2.5 MAF of this total. The portion of the water diverted for irrigation but not actually consumed by crops or other vegetation becomes recharge to the groundwater aquifer or flows back to surface waterways and contributes to surface supplies either within or downstream of the Sacramento Valley.

Land Subsidence

Land subsidence in the Sacramento Valley has resulted from inelastic deformation (non-recoverable changes) of fine-grained sediments related to groundwater withdrawal (California Department of Water Resources 2009b). Additional evaluation is ongoing in larger areas of the valley to provide a regional assessment of subsidence conditions. Further discussion of soil compaction, which resulted in up to 20 feet of subsidence, is provided in Chapter 10, *Soils*. Areas of subsidence from groundwater level declines have been measured in the Sacramento Valley. Several studies performed in the 1990s showed that 4 feet or more of subsidence had occurred since 1954 in some areas, such as in Yolo County (Ikehara 1994). The initial identification of Sacramento Valley subsidence occurred when two extensometers (instruments used for measuring the magnitude of expansion, contraction, or deformation) were installed in Yolo County in 1988 and 1992, and a third was installed in Sutter County in 1994. Initial data from the Yolo County extensometers indicated subsidence in the Davis-Zamora area, which has subsequently been confirmed with a countywide global positioning system network installed in 1999 and monitored in 2002 and 2005. Subsidence up to 0.4 feet occurred between 1999 and 2005 in the Zamora area (Frame Surveying and Mapping 2006).

San Joaquin River Region

Extending south into the Central Valley from the Delta, DWR has delineated nine subbasins within the San Joaquin River Hydrologic Region based on groundwater divides, barriers, surface water features, and political boundaries (California Department of Water Resources 2003): the Cosumnes, East San Joaquin, and Tracy Subbasins that underlie the Delta (described previously), and the Delta-Mendota, Modesto, Turlock, Merced, Chowchilla, and Madera Subbasins (California Department of Water Resources 2003:169) (Figure 7-3).

Groundwater Basin Hydrogeology

The overall origin of San Joaquin Valley groundwater basin sediments is similar to that of the Sacramento Valley: variable north–south deposition of alluvial and outwash sediments from different source areas east and west of the basin. However, depositional conditions in the San Joaquin Valley varied from those in the Sacramento Valley, resulting in substantial hydrogeologic differences between the aquifer systems in the two valleys. These differences include thicker intervals of lacustrine (originating in lakes) and marsh deposits in the San Joaquin Valley groundwater basin, and variations in deeper marine and continental deposits.

Several of the hydrogeologic units in the southern Sacramento Valley extend south into the San Joaquin Valley. Along the eastern portion of the Central Valley, the Ione, Mehrten, Riverbank, and Modesto formations are primarily composed of sediments originating from the Sierra Nevada. Along the western portion of the San Joaquin Valley, the Tulare formation is the primary freshwater unit. It originated as reworked sediments from the Coast Ranges redeposited in the San Joaquin Valley as alluvial fan, flood basin, deltaic (pertaining to a delta) or lacustrine, and marsh deposits (U.S. Geological Survey 1986).

The primary difference between the Sacramento Valley and San Joaquin Valley hydrogeologic units is the presence of thick fine-grained lacustrine and marsh deposits in the San Joaquin Valley. These fine-grained units can be up to 3,600 feet thick in the Tulare Lake region, but more commonly occur as regional, laterally extensive deposits tens to hundreds of feet thick that create vertically differentiated aquifer systems. The most widespread of these units, the Corcoran Clay, occurs in the Tulare formation. Other clay units in the San Joaquin Valley are identified from youngest to oldest by the letters A through F. The E-clay is generally considered to be the Corcoran Clay or its equivalent. These clays are generally thicker and more extensive in the southern portion of the San Joaquin Valley. The Corcoran Clay, for example, is known to occur as far north as Tracy, but is not uniformly identified in the extreme northern part of the San Joaquin Valley. Recharge conditions in the San Joaquin Valley groundwater basin are substantially different from those in the Sacramento Valley groundwater basin. Precipitation in the San Joaquin Valley is much lower than in the Sacramento Valley, ranging from 15 inches in the north to 5 inches per year in the south. Precipitation in the

Sierra Nevada ranges from 20 to 80 inches per year, falling primarily as snow. Annual precipitation rates in the Coast Ranges vary from 10 to 20 inches per year (U.S. Geological Survey 2009). The lower precipitation, combined with hot, dry summers, creates an overall lower rate of groundwater recharge to the San Joaquin Valley aquifer system than in the Sacramento Valley.

Natural recharge to the semi-confined upper aquifer generally occurs from stream seepage, deep percolation of rainfall, and subsurface inflow along basin boundaries. Recharge is augmented with deep percolation of applied agricultural irrigation water and seepage from the distribution systems that convey this water. Recharge to the lower, confined aquifer consists of deep percolation and subsurface inflow from foothill areas east of the Corcoran Clay's eastern boundary. Clay layers, including the Corcoran Clay, are not continuous in some areas and are also penetrated by wells screened above and below the clay. These conditions result in some seepage through the confining layer from the semiconfined aquifer above (Bureau of Reclamation et al. 1999).

Surface water and groundwater are hydraulically connected in most areas of the San Joaquin River and tributaries. Historically, groundwater actively discharged to streams in most of the San Joaquin River Hydrologic Region. After the 1950s, increased groundwater pumping in the region lowered groundwater levels and reversed the hydraulic gradient between the surface water and groundwater systems, resulting in surface water recharging the underlying aquifer system through streambed seepage. Areas where this has occurred include eastern San Joaquin and Merced counties and western Madera County. This is especially true in the Gravelly Ford area, where the riverbed is highly permeable and river water readily seeps into the underlying aquifer. In the northern portions of the San Joaquin River, groundwater levels are shallow and groundwater discharges into the river. The direction of groundwater flow generally coincides with the primary direction of surface water flows in the area, which is to the northwest toward the Delta.

Groundwater levels have declined in the San Joaquin Valley groundwater basin since extensive agricultural development began in the 1940s. Groundwater level declines of up to 100 feet have been exacerbated by droughts and continued increases in groundwater use. Artificial groundwater recharge programs have been developed to replenish groundwater supplies or create groundwater banking programs, primarily in the southern San Joaquin Valley areas (such as Kern County), but other programs are being considered farther north (such as the Madera Groundwater Bank and the City of Tracy).

Prior to the development of the Central Valley, groundwater in the San Joaquin River Hydrologic Region flowed from the valley flanks to the axis, then north toward the Delta. Large-scale groundwater development during the 1960s and 1970s, combined with the introduction of imported surface water supplies, modified the natural groundwater flow pattern. Because of groundwater pumping, groundwater flow largely occurs from areas of recharge toward areas where groundwater pumping has lowered groundwater levels (U.S. Geological Survey 1991).

Groundwater Quality

Groundwater quality varies substantially throughout the San Joaquin Valley groundwater basin. In general, groundwater is of lower quality in this basin compared with the Sacramento Valley groundwater basin. Adverse water quality conditions frequently correlate with the presence of the Corcoran Clay, possibly because the clay restricts vertical flow. Adverse water quality conditions are caused by naturally occurring constituents such as arsenic, molybdenum, iron, and uranium, and by agricultural and industrial contaminants such as perchloroethylene (PCE) and dibromochloropropane (a now-banned nematicide). Each of these constituents can locally or regionally affect the beneficial uses of groundwater in the San Joaquin Valley groundwater basin. Agricultural and industrial contaminants tend to occur in the more urban and southern portions of the San Joaquin Valley groundwater basin. Municipal use of groundwater as drinking water supply is impaired because of elevated TDS concentrations (above the secondary MCL of 500 mg/L) at several locations throughout the San Joaquin River Hydrologic Region (Bureau of Reclamation et al. 1999; California Department of Water Resources 2003).

The water quality in the northwestern part of this basin is variable, with better quality generally found in the northern and eastern parts of San Joaquin and Contra Costa counties as compared to the rest of the area (U.S. Geological Survey 1981). The variation in groundwater quality is attributed to the composition of the subsurface and the quality of the surface water interacting with groundwater. Agricultural practices also may contribute to a degradation of groundwater quality.

Localized groundwater contamination includes industrial organic contaminants such as trichloroethylene (TCE), dichloroethylene, and other solvents. They can be found in groundwater near airports, industrial areas, and landfills (California Department of Water Resources 2003:170).

TDS values vary considerably in the San Joaquin Valley groundwater basin. They are generally lower on the eastern side of the basin than in the west, and are higher in the shallower aquifer than in the deep aquifer. The east–west variability in TDS concentrations reflects the low concentrations of dissolved constituents in recharge water that originates from the Sierra Nevada snowmelt versus the high TDS concentrations of the stream drainage from the Coast Range marine sediments on the western side of the basin. In the trough of the Central Valley, high TDS concentrations result from evaporation and poor drainage, which concentrate salts (California Department of Water Resources 2003).

In the deeper aquifer on the central and eastern side of the valley, TDS concentrations generally do not exceed 500 mg/L. On the western side, TDS concentrations are generally greater than 500 mg/L, and exceed 2,000 mg/L along the western boundary of the valley (Bureau of Reclamation et al. 1999). Concentrations may exceed 2,000 mg/L in the shallow aquifer above the Corcoran Clay throughout the San Joaquin Valley groundwater basin.

Molybdenum, boron, and arsenic are commonly detected at elevated concentrations in groundwater above the Corcoran Clay. Agricultural use of groundwater is impaired because of elevated boron concentrations (greater than 0.75 mg/L) in eastern Stanislaus and Merced Counties. Municipal use of groundwater as a drinking water supply is impaired because of elevated arsenic concentrations (greater than the primary MCL of 50 micrograms per liter) in Stanislaus and Merced Counties and in western San Joaquin County (Bureau of Reclamation et al. 1999).

Groundwater Production and Use

Groundwater production in the San Joaquin Valley groundwater basin occurs from both the shallow and deep aquifers, which are generally separated by the Corcoran Clay or other confining clay intervals. In most areas, groundwater pumping occurs in both aquifers unless local groundwater quality issues exist or if one zone is substantially more permeable.

Groundwater is a major source of water supply for agricultural, municipal, and domestic water supply in the San Joaquin Valley region, accounting for 30% to 40% of the annual agricultural and municipal supply (California Department of Water Resources 2003). Currently, urban and agricultural users on the valley floor are reliant on groundwater for water supply. In fact, groundwater supplies over 75% of water for users on the valley floor (Madera County 2008).

Groundwater is used conjunctively with surface water when those supplies are not sufficient to meet the area's demand for agricultural, industrial, and municipal uses (California Department of Water Resources 2003:169). Most San Joaquin Valley cities rely on groundwater either wholly or partially to meet municipal needs. For example, the Merced area is almost entirely dependent on groundwater for its supply (California Department of Water Resources 2003:169). Groundwater use in the San Joaquin River area is estimated to be between 730,000 and 800,000 acre-feet per year, which exceeds the basin's estimated safe yield of 618,000 acre-feet per year (California Department of Water Resources 2009a). Each groundwater subbasin in this basin has experienced some overdraft (California Department of Water Resources 1994).

Land Subsidence

USGS recognizes four mechanisms of subsidence in the San Joaquin Valley: (1) compaction of fine-grained aquifer materials attributed to groundwater withdrawal; (2) hydrocompaction of unsaturated soils above the water table; (3) oil and gas withdrawal; and (4) neotectonic movement (recent deformation of the earth's crust) (U.S. Geological Survey 1999).

The majority of land subsidence in the southern portion of the San Joaquin Valley groundwater basin is considered to have been caused by groundwater pumping where the Corcoran Clay is present. Groundwater withdrawal has lowered groundwater levels, which allows the compression of the Corcoran Clay and other fine-grained units where groundwater supports the aquifer framework, resulting in inelastic subsidence and causing the overlying ground to lower. Once the inelastic compression occurs, it cannot be restored.

San Joaquin Valley land subsidence is thought to have begun in the 1920s with the advent of irrigated agriculture. Subsidence was first noted in 1941, and detailed study of the causes and magnitude started in the 1950s (U.S. Geological Survey 1975). Subsequent investigations have identified areas of subsidence throughout the valley, with subsidence of 1 foot or more occurring over half of the San Joaquin Valley groundwater basin. Overall subsidence of up to 28 feet has been identified in the Mendota area. Most San Joaquin Valley subsidence is thought to have been caused primarily by deep aquifer system pumping during the 1950s and 1960s, but is considered to have largely abated since 1974 because of the development of more reliable agricultural surface water supplies from the Delta-Mendota Canal and Friant-Kern Canal (U.S. Geological Survey 1999).

Tulare Lake Region

The Tulare Lake Hydrologic Region overlies seven groundwater subbasins, as defined by DWR: the Westside, the Kings, the Tulare Lake, the Kaweah, the Tule, the Pleasant Valley, and the Kern Subbasins (Figure 7-3) (California Department of Water Resources 2003:169).

Groundwater Basin Hydrogeology

The aquifer system in the Tulare Lake region of the San Joaquin Valley groundwater basin consists of younger and older alluvium, flood-basin deposits, lacustrine and marsh deposits and unconsolidated continental deposits. These deposits form an unconfined to semi-confined upper aquifer and a confined lower aquifer in most parts of the Basin. These aquifers are separated by the Corcoran Clay (E-Clay) member of the Tulare Formation, which occurs at depths between 200 and 850 feet along the central and western portion of the basin. Fine-grained lacustrine deposits can be up to 3,600 feet thick in the Tulare Lake region. Groundwater generally flows from the Sierra

Nevada on the east and the Coast Ranges on the west toward the San Joaquin River (California Department of Water Resources 2003).

Since Tulare Lake has dried and is no longer able to recharge the Tulare Lake Basin, groundwater recharge from streams is highly variable and only occurs in wet years. Prior to development, groundwater in both the confined and unconfined aquifers generally moved from recharge areas in the upland areas surrounding the Central Valley toward discharge areas in the lowlands. Groundwater flowed largely toward Tulare Lake. Areal recharge from precipitation provided most of the groundwater recharge, and seepage from stream channels provided the remaining groundwater recharge. Most of this occurred as mountain-front recharge in the coarse-grained upper alluvial fans where streams enter the basin (U.S. Geological Survey 2009). In pre-development years, surface water and groundwater exchange occurred in both directions depending upon variations in hydrologic conditions. When groundwater levels declined due to rapid agricultural growth and heavy groundwater development, the primary interaction of surface water with groundwater became stream flow loss to underlying aquifers. In areas of severe overdraft, such as in Kings County, complete disconnection between groundwater and overlying surface water systems has occurred. Some of these losing streams are now also used as conveyance elements for irrigation purposes and to recharge groundwater. Complete disconnection between groundwater and overlying surface water systems has occurred in the Kern County area. Kern River, a losing stream, is used as a conveyance element for irrigation purposes and to recharge groundwater.

Groundwater levels in most subbasins in the Tulare Lake region have declined over the last 60 years, although in some areas groundwater levels have increased from historic lows in more recent years. Between 1958 and 2006, groundwater levels declined in all subbasins but the Westside. Declines ranged from 20 feet in the Kaweah and Tule Subbasins to 140 feet in the southwest area of the Kings Subbasin (California Department of Water Resources 2011). In the Westside Subbasin, groundwater levels have fluctuated during the past 60 years in response to the availability of surface water deliveries from the CVP. The lowest estimated average groundwater level was 156 feet below sea level and occurred in 1967 (Westlands Water District 2009:9, Table 1). In 2008, however, groundwater levels were estimated at about 11 feet below sea level.

Groundwater levels in the Kern County Subbasin were quite variable in different portions of the basin between 1970 and 2000 (California Department of Water Resources 2006c:3). Between 1958 and 2006, water levels decreased by more than 100 feet in the Bakersfield region (California Department of Water Resources 2011). However, since the late 1970s, groundwater banking operations have helped maintain the groundwater levels fairly static, despite the increase in groundwater extractions in the Bakersfield area. The average change in storage in the Kern County Subbasin between 1970 and 1998 was evaluated to be a decrease of 325,000 acre-feet per year (California Department of Water Resources 2006c:4).

Groundwater Quality

Groundwater quality in the region is generally suitable for most urban and agricultural uses. There are some localized impairments, including high TDS (salts), sodium chloride, sulfate, nitrate, organic compounds, and naturally occurring arsenic. Salinity is the most significant issue facing groundwater in the region due to the impacts of agricultural practices as well as naturally occurring salts in local soils. Because the “greatest long-term problem facing the entire Tulare Lake Basin is the increase of salinity in ground water” (Kern County Water Agency 2011), the Central Valley RWQCB is currently leading an effort to address salinity. An estimated 1,206 tons of salt accumulates annually in the region from imported sources (California Department of Water Resources 2009a, Kern County Water Agency 2011:2-35). This accumulation is trapped and builds up in the underlying aquifers because the Tulare Lake is a closed system without any natural outlets. Agricultural practices also add salts to the system when irrigation water high in salts is applied to the land. This water evaporates and crop transpiration removes water from the soil resulting in salt accumulation in the root zone. This accumulation has to be flushed from the root zone so water eventually percolates into the groundwater. High salt concentrations (greater than the primary drinking water standard) are a particular problem in the western portion of the Tulare Lake region. Shallow groundwater occurs in the western and southern portions of the Kern County Subbasin, which presents problems for agricultural operations (California Department of Water Resources 2006c:4).

Groundwater Production and Use

The Tulare Lake area is heavily groundwater dependent. Groundwater is used conjunctively with surface water when those supplies are not sufficient to meet the region's demand for agricultural, industrial, and municipal uses (California Department of Water Resources 2003:169). Overdraft is a major concern in some areas. Currently, urban and agricultural users on the Valley floor are reliant on groundwater for water supply. For example, the cities of Fresno and Visalia are almost entirely dependent on groundwater for their water supplies, with Fresno being the second largest city in the United States reliant almost solely on groundwater (California Department of Water Resources 2003:177). However, cities in the Tulare Lake area are starting to look for other water sources and some have started groundwater storage programs.

Groundwater use is estimated to account for approximately 41% of the total water supply to the Kern County Subbasin region (Kern County Water Agency 2011:2-27). Agriculture is the largest user of groundwater in the subbasin. Groundwater extractions include urban extraction of 154,000 acre-feet per year, agricultural extraction of 1,160,000 acre-feet per year, and other extractions (oil industry related) of 86,333 acre-feet per year (California Department of Water Resources 2006c: 4). According to Kern County Water Agency, the total estimated water in storage is 40,000,000 acre-feet and dewatered aquifer storage is 10,000,000 acre-feet (California Department of Water Resources 2006c: 3). The City of Bakersfield currently obtains all its delivered water supply through groundwater pumping, which amounts to about 38,700 acre-feet (City of Bakersfield 2007:3.1–3.2). The city water system manages the groundwater basin levels through ongoing recharge projects and has been able to maintain a positive water balance (City of Bakersfield 2007:3.2).

Local and imported surface water supplies are both marked by a high degree of variability, making the region more highly dependent upon groundwater in dry periods (California Department of Water Resources 2009a:TL-19). However, the basin generally underlying the Tulare Lake has experienced a net loss of groundwater storage over the last several decades, indicating that groundwater demands and other outflows have exceeded groundwater inflows in the basin.

Most groundwater subbasins in the Tulare Lake watershed are in a state of overdraft as a consequence of groundwater pumping that exceeds the basin's safe yield (California Department of Water Resources 2003). As a result, the aquifers in these groundwater basins contain a significant amount of potential storage space that can be filled with additional recharged water. Groundwater banking is the storage of excess water supplies into aquifers during wet periods for later withdrawal and use during dry periods (Kern County Water Agency 2011:2-29). The stored water is used through conjunctive use programs by users directly overlying the basin, or it is conveyed to users in regions outside of the groundwater basin. Water for storage may be imported from other regions or agencies for temporary or long-term storage and subsequent export from the basin.

Conjunctive use is an important component of water management in the region, particularly in the Kern County Subbasin. Many groundwater banking facilities supplement water supplies delivered to customers in dry years, when insufficient surface water supplies are available to meet all the requirements. The two major groundwater banking programs in Kern County are the Kern Water Bank operated by the Kern Water Bank Authority and the Semitropic Groundwater Bank, operated by the Semitropic Water Storage District (Semitropic WSD). More than 30,000 acres of groundwater recharge ponds are estimated to exist in the Kern County Subbasin area. The total groundwater banking capacity in the region is estimated at 1.5 MAF per year, with maximum annual recovery estimated at 900,000 acre-feet (Kern County Water Agency 2011:2-30). The long-term storage potential of the Kern County Subbasin is estimated at 8 MAF (Association of Groundwater Agencies 2000:2).

7.1.1.4 Groundwater Setting in the Export Service Areas outside the Delta Watershed

Groundwater resources and groundwater use in the Export Service Areas located outside of the Delta watershed occur in the San Francisco Bay Area, the Central Coast, and Southern California.

San Francisco Bay Area Region

The San Francisco Bay Area covers over 4,600 acres of the coastal plain bounded on the east by the crest of the Coast Ranges mountains. The San Francisco Bay Area includes 28 groundwater basins, as defined by DWR (California Department of Water Resources 2003:131). The most heavily used basins that receive imported water from the Delta include Santa Clara Valley, Napa Valley, and Livermore Valley groundwater basins. Santa Clara Valley WD water supplies include SWP water via the South Bay Aqueduct, CVP water via the San Felipe Division of the CVP, and water from SFPUC's Hetch Hetchy Aqueduct.

The Santa Clara Subbasin has historically experienced decreasing groundwater level trends. Between 1900 and 1960, water level declines of more than 200 feet from groundwater pumping have induced unrecoverable land subsidence of up to 13 feet (Santa Clara Valley Water District 2011). Importation of surface water via the Hetch Hetchy and South Bay Aqueducts and the development of an artificial recharge program have favored the rise of groundwater levels since 1965 (California Department of Water Resources 2004c:2). The Niles Cone Subbasin was in overdraft condition through the early 1960s. In 1962, SWP water was delivered to Alameda County Water District (ACWD) and used to recharge the groundwater subbasin. Since the early 1970s, groundwater levels have risen due to artificial recharge. In the Napa-Sonoma Valley basin, groundwater occurs in confined and unconfined aquifers. Well yields are generally between 10 and 100 gpm, but some areas can yield up to 3,000 gpm. Groundwater in the Napa Valley floor generally flows toward the axis of the valley and then south, except in areas where influenced by groundwater pumping, where local cones of depression exist.

The Livermore Valley groundwater basin contains groundwater-bearing materials originating from continental deposits from alluvial fans, outwash plains, and lakes. Well yields are mostly adequate and in some areas can produce large quantities of groundwater for all types of wells (California Department of Water Resources 2006d:1). The movement of groundwater is locally impeded by structural features such as faults that act as barriers to groundwater flow, resulting in varying water levels in the basin. Groundwater follows a westerly flow pattern, similar to the surface water streams, along the structural central axis of the valley toward municipal pumping centers (Zone 7 Water Agency 2005:3-7). Groundwater levels in the main portion of the Livermore Valley basin started declining in the 1900s, following historical artesian conditions, when groundwater pumping removed large quantities of groundwater. This trend continued through the 1960s. In 1962, Zone 7 Water Agency, which provides water service to the Livermore Valley area, began importing SWP water and later captured local runoff and stored it in Lake Del Valle. The import of additional surface water alleviated the pressure on the aquifer, and groundwater levels started to rise in the 1970s. However, historical lows were reached again during periods of drought.

In the southern San Francisco Bay Area, groundwater and surface water are connected through in-stream and off-stream artificial recharge projects, in which surface water is delivered to water bodies that permit the infiltration of water to recharge overdrafted aquifers. Natural groundwater recharge also occurs from stream seepage during the wet season. Surface water is mostly losing to groundwater, as the groundwater basins have been pumped extensively for various uses.

Groundwater quality in the San Francisco Bay Area is generally good and suitable for most agricultural and municipal uses, but concerns exist about contamination from spills, leaks, and discharges of solvents and fuels affecting beneficial uses, including potable use (California Department of Water Resources 2009a). In basins located near the ocean or where seawater intrusion has occurred, TDS and hardness are issues. Seawater intrusion is prevalent in groundwater basins near San Francisco Bay, northern Santa Clara Valley, and Napa Valley. High TDS and hardness cause pipe scaling and appliance corrosion. Nitrates occur naturally or result from agricultural practices. High Boron levels also occur in the Napa Valley and Livermore Valley basins. Contaminated groundwater from industrial and agricultural chemical spills, underground and above ground storage tank and sump failures, landfill leachate, septic tank failures, and chemical seepage is also an issue in the Bay Area (California Department of Water Resources 2009a).

In the San Francisco Bay Area as a whole, groundwater accounts for 11% of the total agricultural, urban, and environmental water supplies (California Department of Water Resources 2009a, SF-9). In Santa Clara County, approximately 160,000 acre-feet of groundwater is pumped annually by local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (Santa Clara Valley Water District 2011). Alameda County reports that about 31,400 acre-feet of water is pumped annually from the Niles Cone Subbasin for a variety of uses (Alameda County Water District 2011). In Livermore Valley, an average of 25% of the potable water supply produced by Zone 7 comes from groundwater pumped from the basin that has been recharged artificially. In addition, other entities also pump groundwater for potable uses. About 12,000 acre-feet per year of the groundwater extractions include evaporative losses to mining water from the gravel pits (about 3,000 acre-feet per year), municipal pumping by various retailers (about 7,200 acre-feet per year), private pumping, industrial supply and domestic supplies (about 1,200 acre-feet per year), and agricultural pumping for irrigation (about 500 acre-feet per year) (Zone 7 Water Agency 2005:3-9).

Treatment of brackish groundwater is allowing previously unused groundwater to be used as a potable water source. Groundwater desalting is being used to reclaim and improve local brackish groundwater basins. In 2003, the first groundwater desalter went into production. For example, the 5-MGD ACWD Newark Desalination Facility removes salts and other constituents from the Niles Cone Subbasin groundwater for supply as potable water. Also, in 2009, the Zone 7 Water Agency began operation of the Mocho Groundwater Demineralization Plant. This plant produces 6.1 MGD of potable water for blend with other water supply sources.

Conjunctive use and groundwater banking programs have been implemented by several agencies to optimize the use of groundwater and surface water sources. The Santa Clara Valley Water District (SCVWD) operates an extensive system of in-stream and off-stream artificial recharge facilities to replenish the groundwater basin and provide more flexibility to manage water supplies. Eighteen major recharge systems allow local reservoir water and imported water to be released in more than 30 local creeks and 71 percolation ponds for artificial recharge to the groundwater basin. Artificial recharge amounts to approximately 157,000 acre-feet annually (Santa Clara Valley Water District 2011). Recharge in this subbasin occurs naturally along streambeds and artificially in in-stream and off-stream managed basins. The operational storage capacity in the basin was estimated with a groundwater flow model at 350,000 acre-feet, and the rate of withdrawal from the basin is a controlling function; pumping should not exceed 200,000 acre-feet in any single year (Santa Clara Valley Water District 2001:27). Zone 7 Water Agency artificially recharges the Livermore Valley basin with additional surface water supplies by releasing water into the Arroyo Mocho and Arroyo Valle (Zone 7 Water Agency 2005:3-8). The infiltrated water is then pumped from the groundwater basin for various uses.

ACWD, SCVWD, and Zone 7 Water Agency currently have groundwater banking programs. SCVWD reached an agreement with Semitropic WSD to bank up to 350,000 acre-feet in their storage facilities. As of 2001, SCVWD had stored about 140,000 acre-feet in the water banking program (Santa Clara Valley Water District 2001:26).

Central Coast Region

The Central Coast Hydrologic Region includes 50 delineated groundwater basins, as defined by DWR (California Department of Water Resources 2003:140). The basins vary from large extensive alluvial aquifers to small inland valleys and coastal terraces. Groundwater in the large alluvial aquifers occurs in thick unconfined and confined aquifers. Groundwater in the smaller valleys occurs in thinner unconfined aquifers (California Department of Water Resources 2009a:CC-15). Only a few of the DWR groundwater basins underlie areas supplied with Delta water. Most of the groundwater production occurs in the coastal aquifer, though a few large inland valley groundwater basins also provide high yields (Cuyama Valley and Paso Robles area). Production from these basins is tied to groundwater recharge from natural sources (precipitation and stream seepage) and from artificial sources such as reservoir releases to creeks and rivers.

There is significant interaction between surface water and groundwater in the Central Coast, particularly along creeks and rivers. Local agencies operate surface water reservoirs to increase natural recharge by releasing water to recharge downstream groundwater basins. Groundwater recharge is achieved through the operation of several reservoirs: Hernandez Reservoir, Twitchell Reservoir, Lake San Antonio, and Lake Nacimiento. The operation of these reservoirs allows for a continued stream flow over a longer period to increase the infiltration of surface water to the aquifers (California Department of Water Resources 2003:140). For example, Twitchell Reservoir is operated to recharge downstream groundwater basins in the Santa Maria Valley with up to 20,000 acre-feet per year of water (Santa Barbara County 2007:4-17). Lopez Reservoir is operated to supply 4,200 acre-feet per year of water for downstream recharge to groundwater basins. Groundwater recharge occurs primarily from April to October.

According to the Santa Barbara Countywide Integrated Regional Water Management Plan, the Cuyama, San Antonio, and Santa Ynez groundwater basins in Santa Barbara County are in a state of overdraft. The Cuyama Groundwater Basin is in a state of overdraft of approximately 28,525 acre-feet per year based on a 1992 study; the San Antonio Groundwater Basin is in a state of overdraft of approximately 9,540 acre-feet per year based on a 2003 study. The Santa Ynez Uplands Groundwater Basin is currently in a state of overdraft of approximately 2,028 acre-feet per year as reported in a 2001 study (Santa Barbara County 2007: 2-21). Other basins are in equilibrium due to management of the basin through conjunctive use by local water districts. The Goleta Groundwater Basin, which was adjudicated in 1989, generally is near or above historical groundwater conditions (Goleta Groundwater Basin and La Cumbre Mutual Water Company 2010:2-6), with the northern and western portions of the basin having groundwater levels near the ground surface. High groundwater levels may result in degradation to building foundations and agricultural crops (water levels within the crop root zone).

Groundwater levels in the Santa Maria Basin have fluctuated significantly since the 1920s, marked by seasonal and long-term trends of decline and recovery. Declines of up to 100 feet in both the shallow and deep aquifer zones were observed between 1945 and the late 1960s. The groundwater levels have generally recovered; however, groundwater declines in the last decade are visible in portions of the Sisquoc Valley and Oso Flaco areas. Recent groundwater level declines can be attributable, at least partially, to reductions in Twitchell Reservoir releases for in-stream supplemental groundwater recharge since 2000 (including no releases in 2009). Coastal groundwater levels remain above sea level, which indicates that enough recharge is occurring to prevent seawater intrusion (Santa Maria Valley Management Area 2010:8-9).

Groundwater quality issues in the Central Coast area include nitrates, salinity, hardness, and PCE. In the Santa Maria Valley groundwater basin, sulfate and TDS are the primary constituents of concern. TDS concentrations range from approximately 750 mg/L to 1,300 mg/L, with a median of 1,200 mg/L, which exceeds the drinking water standard. All the sulfate concentrations exceeded the recommended drinking water standard of 250 mg/L, and some exceeded the upper limit of 500 mg/L. PCE contamination was a major issue for two wells used by the City of San Luis Obispo in the late 1980s (San Luis Obispo County 2011:3-60). State MCLs for nitrates have been exceeded in some areas of Santa Barbara County, and methyl tertiary butyl ether and chlorinated solvents pose problems for some wells (Santa Barbara County 2007:2-27). In addition, seawater intrusion has been observed more than 5 miles inland in some areas, caused by heavy pumping from municipal wells and a groundwater level drop of up to 100 feet in the late 1970s. (California Department of Water Resources 2003:140).

Groundwater is an important source of water supply for the population of the Central Coast; it is the region’s primary water source. In 1995, groundwater provided approximately 83% of the annual water supply for agricultural and urban uses (California Department of Water Resources 2003:140). Groundwater supplies are from the San Luis Obispo, Los Osos, and the Santa Maria groundwater basins. In Santa Barbara County, over two-thirds of water supplied is from the Santa Ynez River Valley basin, and the major water user is the City of Santa Barbara. In general, this region uses about 8.4% of the groundwater supply in the state.

Southern California Region

Southern California includes the groundwater basins of the South Coast Hydrologic Region, as well as portions of the South Lahontan Hydrologic Region, and the Colorado River Hydrologic Region as defined in DWR Bulletin 118-03. Groundwater occurs in unconfined alluvial aquifers in most of the basins in the South Coast Hydrologic Region. Confined groundwater conditions exist in areas underlying the coastal plains, where multiple aquifers might be separated by aquitards (California Department of Water Resources 2003:149). The South Lahontan Hydrologic Region is sparsely populated and little groundwater development exists in most areas (California Department of Water Resources 2003:194). Several fault zones in Southern California impede groundwater flow in certain areas.

Many rivers in Southern California are intermittent streams that are augmented with releases from reservoirs and treated effluent discharges. Riverbeds are often used to facilitate the recharge of groundwater basins through the porous alluvial material that lines the natural channel bottoms. Groundwater recharge helps alleviate overdraft conditions in these basins.

Currently, over 758,000 acre-feet per year of groundwater is recharged; however, more than 3.2 MAF of storage is available for recharge (Metropolitan Water District of Southern California 2007). Recharge water sources include stormwater, runoff, recycled, and imported water. Over 1,000 acres of basins as well as 36 groundwater injection wells are used to recharge groundwater basins in Southern California to halt the decline of groundwater levels and the intrusion of seawater into aquifers that provide drinking water supplies.

Some of the groundwater basins in Southern California are brackish or have other water quality issues that require additional treatment prior to use. Groundwater quality is degraded through increased salinity and other constituents (such as nitrate) introduced by agricultural and municipal activities, past industrial/commercial activities, seawater intrusion, or from naturally existing conditions. In addition, the use of imported Colorado River water with higher salinities has resulted in degradation of groundwater quality in much of Southern California. Brackish groundwater exists primarily in the San Diego region, areas of the Inland Empire, and coastal areas of Los Angeles and Orange Counties. In addition, high TDS levels are a problem in Coachella Valley. Groundwater quality in the Antelope Valley basin is affected by high levels of nitrate and boron (California Department of Water Resources 2004d:3).

Groundwater is the second largest source of supply used in southern California. In the Metropolitan Water District of Southern California (MWDSC) service area, groundwater supplies meet approximately 40% of the total annual water demand (Metropolitan Water District of Southern California 2007). The major groundwater basins in the region provide an annual average water supply of approximately 1.35 MAF (Metropolitan Water District of Southern California 2010:1–21). Groundwater use in the region tends to be greater in drought years and less in normal and wet years. However, because most groundwater basins in the region are adjudicated, the increase in groundwater pumping during drought years is limited.

Groundwater is the largest source of water supply in Ventura County, where groundwater provides about 67% of the locally used water (Ventura County 2011). Groundwater use in the Antelope Valley is currently estimated to be approximately 90,000 acre-feet per year, which exceeds estimated recharge by approximately 40,000 acre-feet per year (Palmdale Water District 2005).

The Water Replenishment District of Southern California (WRD) manages groundwater in some adjudicated basins in this region. The total adjudicated groundwater amounts to approximately 282,000 acre-feet per year. Currently about 250,000 acre-feet of water are pumped by WRD every year to meet the users' demands (Water Replenishment District of Southern California 2010).

The Coachella Valley (Colorado River Hydrologic Region) relies on a combination of local groundwater, Colorado River water, SWP water, surface water, and recycled water to meet water demands. Coachella Valley Water District (CVWD) supplies all of its domestic water with groundwater and annual sales are nearly 125,000 acre-feet (Coachella Valley Water District 2011).

Many water districts in Southern California have entered into agreements with water banks in Kern and Tulare counties in the Tulare groundwater basins to store water as emergency supplies. The SWP water stored in these groundwater banks outside Southern California is then transferred to the receiving water districts. For example, MWDSC is a groundwater banking partner of the Semitropic WSD.

Groundwater banking also occurs locally in Southern California. For example, the Irvine Ranch Water District (IRWD) has entered into a 30-year water banking partnership with the Rosedale-Rio Bravo Water Storage District in Kern County. IRWD has purchased land overlying the Kern County groundwater basin in the Rosedale Rio Bravo Water Storage District. Both districts collaborated to build 502 acres of recharge ponds to allow available surface water to percolate into the groundwater basin for later use (Irvine Ranch Water District 2011b). Local groundwater banking occurs primarily for storage of Colorado River water, which is conveyed via the Colorado River Aqueduct to the underground storage basins.

7.2 Regulatory Setting

This section provides the regulatory setting for groundwater resources, including potentially relevant federal, state, and local requirements applicable to the BDCP.

Federal laws and regulations that address water quality also may apply to groundwater quality, as presented in Chapter 8, *Water Quality*, and Chapter 10, *Soils,* including Clean Water Act, National Pollutant Discharge Elimination System (NPDES) Program Antidegradation Policy (40 Code of Federal Regulations 131.6); Clean Water Act, Nonpoint Source Management Program (33 United States Code 1329); Clean Water Act, Municipal Separate Storm Sewer Systems (MS4s) policy (40 Code of Federal Regulations 122.34 and 122.26(d); and Safe Drinking Water Act (42 United States Code 300f-300j-26). These regulations are federally mandated and implemented in California through the State Water Resources Control Board. State regulations that address water quality also may apply to groundwater quality, including the Order No. 99-08-DWQ, NPDES General Permit No. CAS000002, Waste Discharge Requirements for Discharges of Stormwater Runoff Associated with Construction Permit (General Permit) as presented in Chapter 8, *Water Quality*, and Chapter 10, *Soils*.

7.2.1 Federal Plans, Policies, and Regulations

Two federal laws, the Safe Drinking Water Act (42 USC 300f) and the Clean Water Act (33 USC 1251–1376), might apply to groundwater. Both regulations are discussed in Chapter 8, *Water Quality.* Implementation of these laws directly or indirectly affects groundwater conditions.

7.2.2 State Plans, Policies, and Regulations

California generally does not regulate the overall use, entitlement, and management of groundwater. Although statewide groundwater regulations have been considered several times in the past, the

California Legislature considers groundwater management to be a local responsibility (California Department of Water Resources 2007). Several state laws specifically address groundwater, and others include groundwater among other physical units, such as surface water. Most of the regulations that include groundwater among other regulated entities are described in Chapter 8, *Water Quality*. State laws that specifically address groundwater as the primary objective or as a major component are presented below.

7.2.2.1 Porter-Cologne Water Quality Control Act (California Water Code, Division 7 and 2009 Amendments)

The Porter-Cologne Water Quality Control Act established surface water and groundwater quality guidelines and provided the authority for the State Water Resources Control Board to protect the state's surface water and groundwater. Nine regional water quality control boards have been established to oversee and implement specific water quality activities in their geographic jurisdictions.

The Porter-Cologne Water Quality Control Act also requires that each regional water quality control board develop basin plans that establish and periodically review the beneficial uses and water quality objectives for groundwater and surface water bodies within its jurisdiction. Water quality objectives developed by the regional boards provide specific water quality guidelines to protect groundwater and surface water to maintain designated beneficial uses. The State Water Resources Control Board, through its regional water quality control boards, is the permitting authority in California to administer NPDES permits and Waste Discharge Requirements for regulation of waste discharges in their respective jurisdictions.

7.2.2.2 Area of Origin Statute (California Water Code 1220)

California Water Code 1220 prohibits the pumping of groundwater "for export within the combined Sacramento and Delta–Central Sierra Basins…unless the pumping is in compliance with a groundwater management plan that is adopted by [county] ordinance." The statute enables, but does not require, the board of supervisors of any county within any part of the combined Sacramento and Delta–Central Sierra Basin to adopt groundwater management plans (GWMPs) (Foley-Gannon 1999).

7.2.2.3 Groundwater Management Act (Assembly Bill 3030)

Assembly Bill (AB) 3030 (1992, California Water Code Sections 10750–10756) enables water agencies to develop and implement GWMPs to manage the groundwater resources in the jurisdiction of the participating parties. The state does not maintain a statewide program or mandate its implementation, but the legislation provides the guidelines and common framework through which groundwater management can be implemented. Groundwater management legislation was amended in 2002 with the passage of Senate Bill (SB) 1938, which provided additional groundwater management components supporting eligibility to obtain public funding for groundwater projects. In 2000, AB 3030 enabled the development of the Local Groundwater Assistance grant program to support local water agencies developing groundwater management programs.

Several GWMPs have been developed in the Delta region (Table 7-4). These plans vary in terms of the groundwater management components and implementation methods included.

1 **Table 7-4 Delta Region Groundwater Management Plans**

Groundwater Basin	Entity/Entities	Document Title	GWMP Report Date	Adoption Date
Sacramento Valley Groundwater Basin (southern portion)				
Cosumnes Subbasin	Southeast Sacramento County Agricultural Water Authority	Southeast Sacramento County Agricultural Water Authority GWMP	12/3/2002	
Solano Subbasin	Assembly Bill 3030 GWMP	City of Vacaville	2/28/1995	2/28/1995
Solano Subbasin	Reclamation District 2068	GWMP	12/2005	12/8/2005
Solano Subbasin	Maine Prairie WD	Maine Prairie WD GWMP	1/21/1997	1/21/1997
Solano, Yolo, Colusa, and Capay Valley Subbasins	Yolo County Flood Control and Water Conservation District	Water Management Plan	6/2006	6/6/2006
South American Subbasin	Sacramento County Water Agency	Central Sacramento County GWMP	2/2006	
South American Subbasin	Sacramento County Water Agency	GWMP	10/26/2004	
South American, North American, and Cosumnes Subbasins	Sacramento Metropolitan Water Authority	GWMP Initial Phase	3/1994	12/11/2003
Yolo Subbasin	City of Davis, University of California at Davis	Groundwater Management Plan	4/2006	5/16/2006
Yolo Subbasin	Reclamation District 2035	GWMP	4/1995	4/25/1995
San Joaquin Valley Groundwater Basin (northern portion)				
Eastern San Joaquin Subbasin	City of Stockton			
Eastern San Joaquin and Cosumnes Subbasins	North San Joaquin WCD	GWMP	9/1995	5/1996
Eastern San Joaquin and Cosumnes Subbasins	Northeastern San Joaquin County Groundwater Banking Authority. Agencies involved: City of Lodi, Woodbridge ID, North San Joaquin WCD, North San Joaquin WCD, Central San Joaquin WCD, Stockton East WD, Central Delta Water Agency, South Delta Water Agency, SJCFCWCD, California Water Service Company, San Joaquin Farm Bureau Federation	Eastern San Joaquin Groundwater Basin GWMP	9/2004	9/22/2004
Eastern San Joaquin Subbasin	South San Joaquin ID	South San Joaquin Irrigation District GWMP	12/1994	2/1995
Eastern San Joaquin Subbasin	Stockton East WD	Stockton East Water District GWMP	10/1995	
Tracy Subbasin	City of Tracy, Banta Carbona ID, Del Puerto WD, Patterson WD, Plain View WD, West Stanislaus ID, Westside ID, SJCFCWCD	Tracy Regional GWMP	5/21/1996	5/21/1996
Tracy and Delta-Mendota Subbasins	San Luis & Delta Mendota Water Authority-North. Other agencies involved: Banta Carbona ID, Del Puerto WD, Patterson WD, Plain View WD, West Stanislaus ID, Westside ID, SJCFCWCD	GWMP for the Northern Agencies in the Delta-Mendota Canal Service Area and a portion of San Joaquin County	10/1995	12/5/1997
Suisun-Fairfield Basin				
Suisun-Fairfield Basin	Solano ID	Assembly Bill 3030 GWMP	2/15/1995	

Source: California Department of Water Resources 2009b

Notes: GWMP = groundwater management plan, ID = irrigation district, SJCFCWCD = San Joaquin County Flood Control and Water Conservation District, WCD = water conservation district, and WD = water district

Table 7-5. Adjudicated Groundwater Basins in Southern California

Basin Name	Date of Final Court Decision	County	Hydrologic Region
Central Basin	1965	Los Angeles	South Coast
Chino Basin	1978	San Bernardino	South Coast
Cucamonga Basin	1978	San Bernardino	South Coast
Main San Gabriel Basin: Puente Narrows	1973	Los Angeles	South Coast
Mojave Basin Area	1996	San Bernardino	South Lahontan
Puente Basin	1985	Los Angeles	South Coast
Raymond Basin	1944	Los Angeles	South Coast
Santa Margarita River Watershed	1966	San Diego	South Coast
Santa Paula Basin	1996	Ventura	South Coast
Six Basins	1998	Los Angeles	South Coast
Tehachapi Basin	1973	Kern	South Lahontan
Upper Los Angeles River Area (including San Fernando Basin)	1979	Los Angeles	South Coast
Warren Valley Basin	1977	San Bernardino	Colorado River
West Coast Basin	1961	Los Angeles	South Coast
Western San Bernardino	1969	San Bernardino	South Coast

Sources: California Department of Water Resources 2003, 2011b

7.2.2.4 Basin Adjudications

Basin adjudications occur through a court decision at the end of a lawsuit. The final court decision determines the groundwater rights of all the groundwater users overlying the basin. In addition, the court decides who the extractors are and how much groundwater those well owners are allowed to extract, and appoints a Watermaster whose role is to ensure that the basin is managed in accordance with the court's decree. The Watermaster must report periodically to the court. There are currently 22 (Table 7-5) adjudicated groundwater basins in California, most of which are located in Southern California.

An adjudication process is currently underway for the Antelope Valley groundwater basin located in Kern and Los Angeles Counties.

7.2.2.5 California Statewide Groundwater Elevation Monitoring Program (CASGEM) (SBX7-6)

SBX7-6, enacted in November 2009, mandates a statewide groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. This amendment to the Water Code requires the collaboration between local monitoring entities and DWR to collect groundwater elevation data. To achieve this goal, DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) Program to establish a permanent, locally-managed program of regular and systematic monitoring in all of the state's alluvial groundwater basins.

SBX7-6 adds to and amends parts of Division 6 of the Water Code, specifically Part 2.11 Groundwater Monitoring. The law requires that local agencies monitor and report the elevation of their groundwater basins. DWR is required by the law to establish a priority schedule for monitoring groundwater basins, and to report to the Legislature on the findings from these investigations (Water Code section 10920 et. seq).

SBX7-6 provides the following.

- Local parties may assume responsibility for monitoring and reporting groundwater elevations.
- DWR works cooperatively with local monitoring entities to achieve monitoring programs that demonstrate seasonal and long-term trends in groundwater elevations.
- DWR reviews prospective monitoring entity submittals, then designates the monitoring entity, notifies the monitoring entity, and makes that information available to the public.
- DWR performs groundwater elevation monitoring in basins where no local party has agreed to perform the monitoring functions.
- If local parties (for example, counties) do not volunteer to perform the groundwater monitoring functions and DWR assumes those functions, then those parties become ineligible for water grants or loans from the state.

The law required local entities to notify DWR in writing by January 1, 2011 if the local agency or party seeks to assume groundwater monitoring functions in accordance with the law. Monitoring Entities were to begin reporting seasonal groundwater elevation measurements on or before January 1, 2012. As part of the CASGEM program, DWR’s role is to work cooperatively with local entities, and to maintain the collected elevation data in a readily and widely available public database. The 2012 CASGEM Status Report to the Legislature describes the progress made in the first two years of this program. In summary, more than 400 monitoring entities have been identified and water level data from the fall 2011 sampling round have been submitted to DWR. DWR is currently developing an online system for a monitoring entity to submit groundwater elevation data, which will be compatible with DWR's Water Data Library.

7.2.3 Regional and Local Plans, Policies, and Regulations

Several counties have adopted or are considering groundwater ordinances applicable to groundwater basins in the Delta Region, the Upstream of the Delta Region, and other portions of the Export Service Areas. The ordinances primarily address well installation, groundwater extraction, and exportation. The counties that incorporate groundwater-related ordinances in the Delta Region, Upstream of the Delta Region, and other portions of the Export Service Areas include Shasta, Tehama, Glenn, Colusa, Yolo, Sacramento, San Joaquin, Calaveras, Tuolumne, Madera, Fresno, Kern, Napa, Ventura, San Diego, and San Bernardino. Local county ordinances vary by authority, agency, or region but typically involve provisions to limit or prevent groundwater overdraft, to regulate transfers, and to protect groundwater quality. For example, San Joaquin County’s groundwater management ordinance was promulgated in 1996. It requires a permit for any groundwater exports from the Eastern San Joaquin County groundwater basin. Before a permit will be issued, an applicant is required to demonstrate that the proposed export will not exacerbate the existing groundwater overdraft condition.

Special Act Districts are created through a special act of the Legislature and are granted greater authority to manage groundwater resources. Currently thirteen such local agencies exist in

California. For example, the Orange County Water District and SCVWD have been granted Special Act District authorities. In general, the specific authority of these districts includes two general categories.

- Limiting export and extraction of groundwater in their jurisdictions (upon evidence of overdraft or threat of overdraft).
- Requiring the users in the basin to report extractions to the agency, who can levy a fee from groundwater management or water supply replenishment.

7.3 Environmental Consequences

This section describes the potential groundwater-related effects that could result from project construction, operation, and maintenance. In general, impacts attributable to construction, dewatering activities, and long-term operation are addressed in the Delta Region. Project implementation also would potentially result in changes in SWP/CVP water supply availability in the Delta Region, Upstream of the Delta Region, and other portions of the Export Service Areas. Changes in SWP/CVP water supply availability could result in changes in groundwater production in areas that use SWP/CVP water supplies.

In the Delta Region, the water table is approximately 5 feet below land surface except in areas adjacent to surface water bodies, where groundwater levels are maintained by island drainage systems to within 1 to 2 feet of the land surface (California Department of Water Resources 2009a). Groundwater levels are influenced throughout the Delta by precipitation, irrigation, interaction with surface water features, subsurface inflow from adjacent areas, evapotranspiration, groundwater pumping, sea level, and agricultural drainage systems. Such drainage systems are operated to keep groundwater below the rooting depths of crops.

The potential for interaction between the canal alignments and the underlying aquifer system in the Delta Region was evaluated using a numerical model, Central Valley Hydrologic Model-Delta (CVHM-D), described in subsection 7.3.1.2, *Analysis of Groundwater Conditions due to Construction and Operations of Facilities in the Delta*. The estimates of groundwater recharge (i.e., seepage) from the canals are described herein on a qualitative basis. This is because future canal seepage rates would be significantly influenced by the built-out design of the canal system. The design approaches being considered to control seepage along various reaches of the canal range from low permeability slurry walls, to passive drain systems, to groundwater interception wells. Each of these approaches would have different levels of effectiveness, and would therefore result in different rates of canal seepage.

In the Sacramento Valley, groundwater levels are generally in balance valley-wide, with pumping matched by recharge from the various sources annually, as described in subsection 7.1.1.3, *Delta Watershed Groundwater Setting.* There are some areas with persistent drawdown, including the northern Sacramento County area, areas near Chico, and on the far west side of the Sacramento Valley in Glenn County. Surface water is provided to several areas within the Sacramento Valley that do not have adequate groundwater supplies, such as the Tehama Colusa Canal Authority service area that uses CVP water supplies.

In the San Joaquin Valley, groundwater levels have been in various rates of decline prior to the 1920s, as described in subsection 7.1.1.3, *Delta Watershed Groundwater Setting*. Land subsidence due to groundwater extraction began in the mid-1920s and accelerated as higher groundwater production rates persisted into the 1970s; groundwater quality degradation, and higher pumping costs have resulted. Historically, the western and southern portions of the San Joaquin Valley are most affected by groundwater-level declines (State Water Resources Control Board and California Environmental Protection Agency 2006).

In portions of the Export Service Areas outside of the Central Valley, basin adjudications and groundwater management programs such as artificial basin recharge have been implemented to help reduce the groundwater overdraft in some basins and reverse the groundwater level decline trend in the San Francisco Bay Area, the Central Coast, and Southern California. Implementation of these types of groundwater management programs are described in subsection 7.1.1.4, *Groundwater Setting in the Export Service Areas outside of the Delta Watershed*.

7.3.1 Methods for Analysis

The groundwater analysis addresses three different aspects of the BDCP. First, the analysis addresses adverse and beneficial changes in groundwater conditions in the areas that use SWP/CVP water in the Delta Region, Upstream of the Delta Region, and other areas of the Export Service Areas due to changes in SWP/CVP water supply availability. Second, the analysis addresses changes in groundwater conditions in the vicinity of the BDCP conveyance facilities (CM1) within the Delta due to construction and operations and maintenance activities. Third, the analysis addresses changes in groundwater conditions due to the construction and implementation of restoration actions in areas within the Delta where other conservation measures could be implemented.

7.3.1.1 Analysis of Groundwater Conditions in Areas that Use SWP/CVP Water Supplies

Changes in SWP/CVP water supply availability, as described in Chapter 5, *Water Supply,* could result in changes in groundwater conditions in those areas, as observed from historical trends described in Section 7.1.1.3. It is assumed that in areas that experience increased SWP/CVP water supplies, groundwater withdrawals would decline, and depending upon the local groundwater characteristics, groundwater elevations may rise. It is further assumed that if SWP/CVP water supplies decrease in areas that have historically relied upon groundwater for major portions of the water supply, groundwater withdrawals would increase to replace the reduction in SWP/CVP surface water supplies.

There could be minor decreases in water supply availability to CVP water users in the Sacramento Valley service area due to the implementation of the alternatives. These minor changes have been estimated at approximately 50,000 acre-feet per year, which is approximately 2% of the current annual average groundwater production quantity in the Sacramento Valley. The Sacramento Valley Groundwater Basin is “full” in most areas, except during droughts and in a few locales where drawdown has been observed over the years. In most areas groundwater levels recover to pre-irrigation season levels each spring. A 2% increase in groundwater use in the Sacramento Valley to make up for any shortfalls in surface water supply is not anticipated to substantially impact the groundwater resources as long as the additional pumping is not concentrated in a particular area of the valley. Therefore, the Sacramento Valley Groundwater Basin is not included in the groundwater analysis presented in this chapter.

To capture the correlation between surface water deliveries and groundwater withdrawals, and the associated impacts on groundwater in the San Joaquin Valley and Tulare Lake basins, the impact analysis was conducted using CVHM. CVHM is a three-dimensional numerical groundwater flow model developed by the USGS and documented in Groundwater Availability of the Central Valley Aquifer, California (U.S. Geological Survey 2009). CVHM simulates primarily subsurface and limited surface hydrologic processes over the entire Central Valley at a uniform grid-cell spacing of 1 mile. Figure 7-4 shows the CVHM domain and a description of CVHM is provided below.

The analysis evaluates groundwater conditions using the following comparisons:

- Existing Conditions (without sea level rise or climate change [i.e., effects on precipitation and snowpack]) and the No Action Alternative (with sea level rise and climate change that would occur in the late long-term [LLT] timeframe, or around Year 2060).
- Existing Conditions (without sea level rise or climate change) and BDCP alternatives (with sea level rise and climate change that would occur in the LLT timeframe, or around Year 2060).
- The No Action Alternative and BDCP alternatives (both with sea level rise and climate change that would occur in the LLT timeframe, or around Year 2060).

The results of the comparison of Existing Conditions to the BDCP alternatives reflect differences in groundwater conditions resulting from the difference in SWP/CVP surface water supply availability due to changes in SWP/CVP operations under the BDCP alternatives and due to sea level rise and climate change.

The results of the comparison of the No Action Alternative to the BDCP alternatives reflect differences in groundwater conditions resulting from the difference in SWP/CVP surface water supply availability due to changes in SWP/CVP operations under the BDCP alternatives only.

In noting effects under different SWP/CVP operational scenarios under LLT around Year 2060 conditions, readers should be aware that some of the differences between those anticipated future conditions and Existing Conditions (for CEQA) are attributable to sea level rise and climate change, and not to the operational scenarios themselves. Many of the figures in this chapter depicting differences between alternatives under LLT conditions and the CEQA Existing Conditions baseline may therefore seem to exaggerate the effects of proposed operational changes. In some of these figures, the environmental changes depicted are largely attributable to sea level rise and climate change (i.e., anticipated reductions in snowfall and effects on precipitation generally).

Describing Changes due to Sea Level Rise and Climate Change as Compared to Changes due to New Facilities and Operations

As is the case throughout this document, effects are analyzed in this chapter under both NEPA and CEQA, with the NEPA analysis being based on a comparison of the effects of action alternatives against a future No Action condition and the CEQA analysis being based on a comparison of these effects against Existing Conditions. One consequence of the different approaches is the manner in which sea level rise and climate change are reflected in the respective impact conclusions under the two sets of laws. Under NEPA, the effects of sea level rise and climate change are evident both in the future condition and in the effects of the action alternatives. Under CEQA, in contrast, the absence of sea level rise and climate change in Existing Conditions results in model-generated impact conclusions that include the impacts of sea level rise and climate change with the effects of the action alternatives. As a consequence, the CEQA conclusions in many instances either overstate the effects of the action alternatives or suggest significant effects that are largely attributable to sea level rise and climate change, and not to the action alternatives.

In both sets of analyses, the Lead Agencies have relied on computer models that represent best available science; however, any predictions of conditions 50 years from the present are inherently limited and reflect a large degree of speculation. In the interest of informing the public of what DWR believes to be the reasonably foreseeable impacts of the action alternatives, DWR has focused primarily on the contribution of the action alternatives, as opposed to the impacts of sea level rise and climate change, in assessing the significance of the impacts of these action alternatives. The opposite approach, which would treat the impacts of sea level rise and climate change as though they were impacts of the action alternatives, would overestimate the effects of the action alternatives. The approach taken here by DWR also has the effect of highlighting the substantial nature of the consequences of sea level rise and climate change on California's water system.

As described in Chapter 5, *Water Supply*, the differences in SWP/CVP surface water supply availability under a BDCP alternative as compared to Existing Conditions were frequently more related to changes in sea level rise and climate change than to SWP/CVP operations under the BDCP alternative. More details on these effects are described in Chapter 5, *Water Supply*.

For each alternative, the following impact assessment comparisons are presented for the quantitative analyses of groundwater level changes and associated impacts in the Delta and in the Export Service Areas.

- Comparison of each alternative (at LLT) to Existing Conditions (the CEQA baseline), which will result in changes in SWP/CVP water supply conditions that are caused by three factors: sea level rise, climate change, and implementation of the alternative. It is not possible to specifically define the exact extent of the changes due to implementation of the alternative using the model simulation results presented in this chapter. Thus, the precise contributions of sea level rise and climate change to the total differences between Existing Conditions and LLT conditions under each alternative cannot be isolated.
- Comparison of each alternative (at LLT) to the No Action Alternative (the NEPA baseline) to indicate the general extent of changes in SWP/CVP water supply conditions due to implementation of the alternative. Because sea level rise and climate change are reflected in each action alternative and in the No Action alternative, this comparison reflects the extent of changes in SWP/CVP water supplies attributable to the differences in operational scenarios amongst the different action alternatives.

For the other Export Service Areas in the San Francisco Bay Area, the central Coast, and southern California, no regional models are available, and the discussion of impacts is qualitative.

Central Valley Hydrologic Model Methodology

CVHM simulates surface water flows, groundwater flows, and land subsidence in response to stresses from water use and climate variability throughout the entire Central Valley. It uses the MODFLOW-2000 (U.S. Geological Survey 2000b) groundwater flow model code combined with a module called the Farm Process (FMP) (U.S. Geological Survey 2006c) to simulate groundwater and surface water flow, irrigated agriculture, and other key processes in the Central Valley on a monthly basis from April 1961 through September 2003. The CVHM domain is subdivided laterally into 1-square-mile grid-blocks over a 20,000-square-mile area, and vertically into 10 layers ranging in thickness from 50 feet near the land surface to 750 feet at depth. The thinner layers near the land surface provide for more detailed estimates of groundwater impacts near the project facilities.

FMP allocates water, simulates processes, and computes mass balances for 21 defined subregions of the model domain. These subregions are referred to as Water Budget Subareas and "farms" in CVHM. FMP was developed for MODFLOW-2000 to estimate irrigation water allocations from conjunctively used surface water and groundwater. It is designed to simulate the demand components representing crop irrigation requirements and on-farm inefficiency losses, and the supply components representing surface water deliveries and supplemental groundwater pumping. FMP also simulates additional head-dependent inflows and outflows such as canal losses and gains, surface runoff, surface water return flows, evaporation, transpiration, and deep percolation of applied water. Unmetered pumping and surface water deliveries for the 21 WBSs are also included within FMP.

CVHM, which uses results from CALSIM II (see Chapter 5, *Water Supply*, Section 5.3.1, and Chapter 6, *Surface Water*, Section 6.3.1, for further description of the assumptions associated with CALSIM II modeling for Existing Conditions, the No Action Alternative, and the BDCP action alternatives), was calibrated using a combination of trial-and-error and automated methods. An autocalibration code, UCODE-2005 (U.S. Geological Survey 2005), was used to help assess the ability of CVHM to estimate the effects of changing stresses on the hydrologic system. Simulated changes in water levels, streamflows, streamflow losses, and land subsidence through time were compared with those measured at wells, streamflow gages, and extensometers. For model calibration, groundwater levels and surface water stages were assimilated to establish calibration-target locations distributed spatially (geographically and vertically) throughout the Central Valley, distributed temporally throughout the simulation period (1961–2003), and with available data during wet and dry climatic regimes. From the available well records, a subset of 170 comparison wells was selected on the basis of perforation depths, completeness of record, and locations throughout the Central Valley (U.S. Geological Survey 2009). For additional information, see Appendix 7A, *Groundwater Model Documentation*.

Effects associated with changing groundwater use in the Export Service Areas in the San Joaquin Valley were evaluated using CVHM. The Delta exports simulated by CALSIM II were used as inputs into CVHM to assess impacts on groundwater levels due to changes in surface water deliveries. Because CALSIM II assumes the same deliveries for the different types of conveyance per alternative, CVHM also used only one delivery time series per alternative (not distinguishing any "sub-alternative;" e.g., 1A, 1B, 1C). Therefore, the impacts for Alternative 1A, 1B, and 1C are assumed to be the same within the Export Service Areas. Similarly, impacts for Alternatives 6A, 6B, and 6C are also assumed to be the same within the Export Service Areas. The same holds true for Alternatives 2A, 2B, and 2C.

7.3.1.2 Analysis of Groundwater Conditions Associated with Construction and Operations of Facilities in the Delta

The analysis describes the potential for temporary construction and long-term operations activities to directly or indirectly affect groundwater resources associated with the following BDCP conveyance concepts.

- Pipeline/Tunnel (Alternatives 1A, 2A, 3, 5, 6A, 7, and 8).
- East Alignment (unlined and lined canal) (Alternatives 1B, 2B, and 6B).
- West Alignment (unlined and lined canal) (Alternatives 1C, 2C, and 6C).
- Modified Pipeline/Tunnel (Alternative 4).

- Through Delta/Separate Corridors (Alternative 9).

The analysis relies upon geospatial information identifying temporary ground-disturbing activities necessary for project construction in the Delta Region. Longer-term effects resulting from the physical footprints of water conveyance facilities and conservation areas, as well as operational effects on groundwater resources are described separately. Areas south of the Delta that receive Delta water would not be affected during construction activities in the Delta because the changes in groundwater levels due to construction dewatering occur locally around the site of dewatering and are not propagated into other groundwater basins. During construction activities, the Delta exports are assumed to remain identical to what they would be without construction activities associated with the new conveyance facility.

CVHM-D was used to evaluate the effects of the construction and long-term operation of the water conveyance facilities associated with BDCP on groundwater resources in the Delta Region. CVHM-D is essentially a higher resolution version of CVHM with a smaller model domain footprint centered on the Delta Region that simulates hydrologic processes in the Delta Region at a more refined grid-cell spacing of 0.25 mile (compared with the grid-cell spacing of 1 mile with CVHM). Other enhancements were incorporated in CVHM-D, as described below. Figure 7-5 shows the CVHM-D domain in relation to the CVHM domain. The main activity evaluated for the construction phase was the dewatering associated with the construction of pump stations, canal crossings, and other project facilities. The parameters used to simulate the dewatering projects were obtained from two DWR technical memoranda: *Definition of Existing Groundwater Regime for Conveyance Canal Dewatering and Groundwater Evaluation* (California Department of Water Resources 2010a) and *Analysis of Dewatering Requirements for Potential Excavations* (California Department of Water Resources 2010b). Each dewatering project was simulated using CVHM-D. The effects of each dewatering simulation were compared to the simulation of the No Action Alternative baseline conditions to obtain an estimate of the incremental impacts of dewatering activities. CVHM-D results were used to support the analysis in the Environmental Consequences assessment. The conveyance facilities could include various structures including low-permeability cut-off walls, toe drains, or other structures that could affect groundwater resources during long-term operation. The conveyance features for each alternative were incorporated into CVHM-D as boundary conditions using various MODFLOW packages as described in Appendix 7A, *Groundwater Model Documentation*. In addition, surface water inflows for streams affected by operational changes were estimated from CALSIM II simulations for each alternative and incorporated into CVHM-D.

For the portion of the impacts analysis described herein using CVHM-D, the Existing Conditions baseline was considered comparable to the No Action Alternative without sea level rise and climate change, as Delta flows do not change substantially between the two scenarios, and no new conveyance is built in the Delta under either scenario that could result in differential impacts. Therefore, results for CEQA conclusions are presented via a comparison of each BDCP alternative with the No Action Alternative without sea level rise and climate change.

Central Valley Hydrologic Model–Delta Methodology

The objectives of Central Valley Hydrologic Model–Delta (CVHM-D) were to develop a model capable of being accurate at scales relevant to water-management decisions and to develop a better understanding of the flow system at a regional scale (correlating to the original water budget subareas defined by USGS, 2009). The more generalized Central Valley Hydrologic Model (CVHM), contains sufficient fundamental information to facilitate the addition of more detailed features that may be relevant at a subregional scale (U.S. Geological Survey 2009). However, evaluating the potential impacts of the BDCP alternatives on groundwater resources in the Delta Region required modification of CVHM. Five fundamental modifications were made to CVHM for application to this project.

- Model domain extent of CVHM was reduced to include only the Delta Region.
- Model grid-cell spacing was reduced from 1-mile to 0.25-mile centers.
- The original Water Budget Subarea 9 for CVHM was split into smaller water budgets subareas.
- Additional streams, sloughs, and canals were incorporated.
- Boundary conditions in the Delta Region were refined to allow for more precise simulation of water routing in the Delta Region, as compared to CVHM.

The CVHM domain was reduced by eliminating most of the Sacramento Valley and San Joaquin Valley from the domain when developing CVHM-D. This modification allowed for greater precision in model output in the Delta Region. Modifying the extent of the model domain required the assignment of boundary conditions on the northern and southern edges of CVHM-D. These boundary conditions were specified as General Head Boundaries (GHBs) with associated groundwater heads that reflect groundwater levels consistent with monthly groundwater level output from CVHM. Thus, CVHM was run initially to assign transient groundwater levels to the GHBs on the northern and southern boundaries of CVHM-D. This methodology ensured that the information contained in the overall CVHM was transferred to the refined scale CVHM-D. In addition, some streams flow from the original CVHM domain into the CVHM-D domain. The CVHM flows were used as boundary inflows into the CVHM-D domain. Figure 7-5 shows the CVHM-D domain.

The resolution of the CVHM-D grid was increased to improve the depiction of the physical configuration of the surface water features that exist within the Delta Region and to improve the precision of estimates of impacts on groundwater resources from project construction and operation. Further, CVHM includes explicit representation of only the primary rivers that enter the Delta Region and represents the remainder of the Delta as a large groundwater discharge area, which is simulated using a GHB boundary condition. To more accurately evaluate the effects of the Alternatives on streamflows and surface water/groundwater interaction, a more detailed representation of the stream, slough, and canal networks in the Delta was required. These water courses were digitized from USGS maps and included in CVHM-D. For additional information, see Appendix 7A, *Groundwater Model Documentation*.

7.3.1.3 Analysis of Conservation Measures 2–22 in the Delta

Because conservation activities planned within the Delta for CM2–CM22 are conceptual at this point, this analysis took a programmatic approach to addressing effects on groundwater resources using similar analytical approaches and tools for the placement of structural facilities. These effects are included in Section 7.3.3, *Effects and Mitigation Approaches*; however, they will also be discussed in greater detail and specificity in subsequent project-level environmental documentation after the specific locations of CM2–CM22 are determined. Therefore, impacts related to the implementation of the restoration areas in the Delta Region are described in qualitative terms.

7.3.2 Determination of Effects

Potential impacts associated with groundwater resources were evaluated based on the four criteria listed below. Each of these criteria was in turn used to capture potential effects during construction, operation, and maintenance of the water conveyance facilities (CM1), and implementation of the CM2–CM22, as applicable. Effects on groundwater resources were considered adverse under NEPA and significant under CEQA if implementation of an alternative would result in any of the following conditions.

- Deplete groundwater supplies or interfere with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level that would reduce well yields to a level that would not support existing land uses or planned uses for which permits have been granted (referred to as Impact GW-1 and GW-2 from construction and operation, respectively, in the Delta Region and as Impact GW-6 from operation in the Export Service Areas). For the purposes of this analysis, "a lowering of the local groundwater table level that would reduce well yields to a level that would not support existing or planned land uses" is defined as circumstances in which temporary construction dewatering activities lowers local groundwater levels in shallow wells and reduces the well yield significantly such that existing land uses cannot be sustained. During operations of conveyance, this impact is defined as circumstances in which local groundwater levels are lowered in nearby wells such that existing and planned land uses cannot be sustained. In this case, shallow domestic wells might be affected, while deep agricultural or municipal wells might not be affected. The distinction in well depth is provided in the impacts analysis. The pumping of a well depresses the water table in the immediate vicinity, which in turn decreases the saturated thickness available to near-by wells. This reduction in saturated thickness results in a diminished well yield from those affected wells.

- Degrade groundwater quality (referred to as Impact GW-3 and GW-7 in the Delta Region and Export Service Areas, respectively, during both construction and operation). For the purposes of this analysis, "degrade groundwater quality" is defined as circumstances in which changes in groundwater flow directions would result in poor groundwater quality migration into areas of better quality groundwater.

- Interfere with agricultural drainage in the Delta Region due to the construction and operation of conveyance facilities and restoration areas (referred to as Impact GW-4 and GW-5 from construction and operation, respectively, in the Delta Region). For the purposes of this analysis, "interfere with agricultural drainage" is defined as circumstances in which 1) shallow groundwater levels rise near the land surface (or plant root zone) and interfere with existing drainage systems or require the installation of such systems to allow for optimal crop growth, or 2) shallow groundwater flow directions are altered such that existing drainage systems would no longer be functional.

- Result in groundwater level-induced land subsidence in the Export Service Areas (referred to as Impact GW-8 from operation in the Export Service Areas). For purposes of this analysis, "groundwater level-induced land subsidence" is defined as circumstances in which confined groundwater levels decrease such that unconsolidated materials undergo compaction resulting in inelastic subsidence of the land surface.

As discussed in greater detail in Chapter 5, *Water Supply*, Section 5.3.2, the NEPA No Action Alternative, which reflects an anticipated future condition in 2060, includes both sea level rise and climate change (changed precipitation patterns), and also assumes, among many other programs, projects, and policies, implementation of most of the required actions under both the December 2008 USFWS BiOp and the June 2009 NFMS BiOp. The NEPA effects analyses in this chapter reflect these No Action assumptions.

7.3.3 Effects and Mitigation Approaches

The assessment of effects resulting from implementation of the BDCP alternatives is complicated by the fact that locations and construction details for existing production wells in the vicinity of the project are unknown at this time. Most wells in the project area are private domestic or agricultural wells and their locations and production rates are not publicly available. Therefore the model predictions of changes in groundwater levels or flow directions cannot be correlated to a particular well that may potentially be affected. The approach used herein is to make general inferences regarding well construction and land use, and then evaluate whether the forecasted impacts have the potential to significantly affect existing wells. For instance, if forecasted impacts indicate a reduction in saturated thickness will occur, and well yields are inferred to be reduced enough to no longer sustain current and planned land uses for which permits have been granted, then that particular alternative was deemed to have the potential to result in significant impacts.

The distribution of groundwater quality across the project areas is not available in the Delta as water quality monitoring of wells in the Delta is not routinely performed. In the SWP/CVP Export Service Areas, available information on groundwater quality issues is described in the Affected Environment Section. The approach used herein to identify areas of potential groundwater quality degradation is to infer how groundwater flow directions would change upon project implementation. This was done by comparing simulated groundwater flow patterns before and after project implementation.

If no significant regional changes in groundwater flow directions are forecasted, then it is inferred that the potential for inducement of poor quality groundwater into areas of better quality is unlikely. This approach may not account for the groundwater degradation that could result from the presence of existing localized areas of poor quality groundwater (such as that resulting from a leaky fuel tank or other point release).

As described in the Methodology Section, CVHM simulations output describes monthly results over a total of 510 simulation intervals, referred to as stress periods (the entire simulation runs for 42.5 years between April 1964 and September 2003), that are each compared to baseline conditions. The resulting water level changes for all 510 monthly stress periods were plotted on a map and for each alternative, a typical groundwater level change in the Service Areas was chosen. The maximum groundwater level changes are typically reached in August, when the irrigation season is at its peak. Therefore, this was the month of choice for the evaluation of impacts in the Service Areas. Maps comparing the groundwater conditions under each alternative to the baseline condition are provided for each alternative and groundwater level changes are discussed.

7.3.3.1 No Action Alternative

The No Action Alternative includes continued implementation of SWP/CVP operations, maintenance, enforcement, and protection programs by federal, state, and local agencies, as well as projects that are permitted or under construction. A complete list and description of programs and plans considered under the No Action Alternative is provided in Appendix 3D, *Defining Existing*

Conditions, No Action Alternative, No Project Alternative, and Cumulative Impact Conditions. Operations of the SWP and CVP facilities would change under the No Action Alternative due to increased water rights demands and implementation of a provision in U.S. Fish and Wildlife Service 2008 BiOp (see Chapter 5, *Water Supply* and Chapter 6, *Surface Water*, for more details).

For discussion purposes, groundwater conditions analyzed under the No Action Alternative and compared to Existing Conditions are described on a subarea basis summarized below.

- Delta Region
    - **North Delta.** This subregion comprises CVHM-D Water Budget Subarea (WBS) 22, shown in Figure 7-5.
    - **Central Delta.** This subregion comprises CVHM-D WBSs 23–33, 40–42, and 44, shown in Figure 7-5.
    - **South Delta.** This subregion comprises CVHM-D WBSs 34–39 and 43, shown in Figure 7-5.
- Export Service Areas
    - **San Joaquin Basin.** This subregion includes CVHM WBSs 10, 12, and 13, shown in Figure 7-4.
    - **Tulare Basin.** This subregion includes CVHM WBSs 14–21, shown in Figure 7-4.
    - **Other Portions of the Export Service Areas.** The San Francisco Bay Area, Central Coast, and Southern California were analyzed qualitatively.

Delta Region

The following is a brief discussion on how groundwater levels are expected to vary under the No Action Alternative. Water level descriptions are based on CVHM-D simulation results. Groundwater resources are not anticipated to be substantially affected in the Delta Region under the No Action Alternative because surface water inflows to this area are sufficient to satisfy most of the agricultural, industrial, and municipal water supply needs. Groundwater use in the Delta Region is limited primarily because of high salinity, particularly for municipal and industrial uses. In the North Delta, groundwater is assumed to be used only as a supplemental source of supply for agriculture.

North Delta

Forecasted groundwater flow in the north Delta under Existing Conditions is generally to the south and toward the Sacramento River and Deep Water Ship Channel, which are oriented in a north-south direction. The average of the monthly forecasted groundwater levels for irrigated areas within the north Delta typically range from -10 to -5 feet above the National Geodetic Vertical Datum of 1929 (NGVD29) over the 42-year simulation period. No long-term increasing or decreasing groundwater-level trends are forecasted in the North Delta.

Central Delta

Forecasted groundwater flow in the central Delta under Existing Conditions is complex because of the spatially variable water use (e.g., drainage pumping, irrigation, etc.) and island, slough, stream, canal, and levee configurations therein. However, regionally groundwater is forecasted to flow from east to west toward the confluence of the Sacramento and San Joaquin Rivers in the western Delta. The average of the monthly forecasted groundwater levels for irrigated areas within the central

Delta typically range from -20 feet to -1 foot NGVD29 over the 42-year simulation period. No long-term increasing or decreasing groundwater-level trends are forecasted in the Central Delta.

South Delta

Forecasted groundwater flow in the south Delta under Existing Conditions is complex because of the spatially variable water use (e.g., drainage pumping, irrigation, etc.) and island, slough, stream, canal, and levee configurations therein. However, regionally forecasted groundwater flow in the south Delta is generally north-northwest toward the confluence of the Sacramento and San Joaquin Rivers in the western Delta. The average of the monthly forecasted groundwater levels for irrigated areas within the South Delta typically range from -18 to -3 feet NGVD29 over the 42-year simulation period, except in WBS 38 and WBS 39 in the south and southeast portions of the South Delta. The average of the monthly forecasted groundwater levels for irrigated areas within WBS 38 and WBS 39 typically range from 1 to 25 feet NGVD29 over the 42-year simulation period. No long-term increasing or decreasing groundwater-level trends are forecasted in the South Delta.

Groundwater conditions under the No Action Alternative (with future projected sea level rise and climate change at approximately year 2060) compared to Existing Conditions are provided in the descriptions that follow. The comparison is made through a review of simulated groundwater resources conditions in the Delta.

Changes in Delta Groundwater Levels

Groundwater levels in the Delta for the No Action Alternative would be strongly influenced by surface water flows in the Sacramento River that fluctuate due to sea level rise, climate change and due to surface water operations.

Compared with Existing Conditions, forecasted groundwater levels would increase by up to 5 feet in the Suisun Marsh area in the No Action Alternative; the increase is due to sea level rise in San Francisco Bay. This incremental increase in groundwater level in the No Action Alternative is not expected to cause adverse effects on nearby well yields and might actually result in a beneficial effect on shallow well yields. In other areas of the Delta, groundwater levels would be similar under Existing Conditions as compared to the No Action Alternative.

Changes in Delta Groundwater Quality

As described above, groundwater levels would be similar under Existing Conditions and the No Action Alternative except for a localized area around Suisun Marsh. Therefore, changes in groundwater conditions under the No Action Alternative are not anticipated to alter regional patterns of groundwater flow or quality, compared with Existing Conditions. Minor groundwater quality effects due to seawater intrusion might occur; however, no groundwater salinity simulations are available to verify this hypothesis.

Changes in Delta Agricultural Drainage

Due to fluctuations in groundwater levels that occur with sea level rise and climate change, some areas of the Delta might experience rises in groundwater levels in the vicinity of rivers and in the Suisun Marsh area under the No Action Alternative compared to Existing Conditions. This could affect agricultural drainage. However, changes are anticipated to be minor and these areas would be surrounded by larger regional flow patterns that would remain largely unchanged under the No Action Alternative.

SWP/CVP Export Service Areas

Under the No Action Alternative, surface water supplies to the Export Service Areas would continue to decline based on water modeling and operational assumptions described in Chapters 5 and 6 which project reductions in SWP/CVP water supply availability, compared to Existing Conditions. In addition, decreases in SWP/CVP surface water deliveries in the Export Service Areas for the No Action Alternative compared to Existing Conditions also occur due to sea level rise and climate change, as described in Chapter 5, *Water Supply*.

Under the No Action Alternative, it is assumed that land use remains constant at Year 2000 conditions over the 42-year simulation period; however, numerous political, economic, and environmental factors could result in land use changes. The 2000 land use input files were the latest available from the CVHM (U.S. Geological Survey 2009).

Groundwater conditions under the No Action Alternative (with future projected sea level rise and climate change at approximately year 2060) compared to Existing Conditions are provided in the descriptions that follow. The comparison is made through a review of simulated groundwater resources conditions in the San Joaquin and Tulare Basins.

San Joaquin Basin

Forecasted groundwater flow in the San Joaquin Basin under the No Action Alternative is generally toward the San Joaquin River from the margins of the basin and to the northwest toward the Delta. As compared to Existing Conditions, groundwater levels would decline by up to 25 feet beneath the Corcoran Clay in portions of the San Joaquin Basin (see Figure 7-6) under the No Action Alternative. This would be considered an adverse effect on groundwater resources.

Tulare Basin

Forecasted groundwater flow in the Tulare Basin under the No Action Alternative is complex because of the spatially variable water use over such a large area. Forecasted groundwater flow in the Tulare Basin is generally away from the margins of the basin toward areas of substantial groundwater production. As compared to Existing Conditions, groundwater levels would decline as much as 250 feet beneath the Corcoran Clay in dry years in portions of the Tulare Basin irrigated areas, notably the Westside and Northern Pleasant Valley basins (WBS 14) in the western portion (see Figure 7-6) under the No Action Alternative. The forecasted maximum groundwater level changes occur in August because agricultural groundwater pumping is typically highest during this month. This would be considered an adverse effect on groundwater resources.

The increase in groundwater pumping that could occur under the No Action Alternative compared to Existing Conditions in portions of the Export Service Areas in response to reduced SWP/CVP water supply availability could induce the local migration of poor-quality groundwater into areas of good-quality groundwater. However, it is not anticipated to alter regional groundwater flow patterns and would not be considered an adverse effect.

Forecasted land subsidence estimates indicate that most of the Export Service Areas under the No Action Alternative compared to Existing Conditions would see land subsidence of no more than a hundredth of an inch on average. Therefore, the potential for substantial land subsidence from groundwater pumping from implementation of the No Action Alternative is low, and would not be considered an adverse effect.

Other Portions of the Export Service Areas

The total long-term average annual water deliveries to the CVP and SWP Export Service Areas in portions outside of the Central Valley under the No Action Alternative would be less than under Existing Conditions. If less surface water is available for municipal, industrial, and agricultural users, utilization of groundwater resources would be increased (see Chapter 5, *Water Supply*). However, in the Central Coast and Southern California, overdrafted basins have, for the most part, been adjudicated to control the amount of pumping, thus reducing the amount of groundwater resource availability.

In addition, many groundwater basins in the San Francisco Bay Area, Central Coast, and Southern California rely on SWP/CVP surface water to recharge groundwater basins. Therefore, adverse effects on groundwater supplies, groundwater recharge, and local groundwater table levels are expected to result under the No Action Alternative in these Export Service Areas. This would also reduce the amount of groundwater resources availability.

Ongoing Plans, Policies, and Programs

The programs, plans, and projects included under the No Action Alternative are summarized in Table 7-6, along with their anticipated effects on groundwater resources. In summary, these projects are not anticipated to have any adverse effects on groundwater resources.

CEQA Conclusion: Due to the decrease in availability of SWP and CVP deliveries to the Export Service Areas under the No Action Alternative as compared to existing conditions, groundwater pumping will increase in some areas. This would result in a corresponding decrease in groundwater levels which could significantly affect the yield of domestic, municipal and agricultural wells. Migration of poor quality groundwater into areas of better quality groundwater might also occur. Impacts on groundwater levels and groundwater quality in the Export Service Areas are considered significant under the No Action Alternative.

In total, the ongoing programs and plans under the No Action Alternative would not result in significant impacts on groundwater resources based upon information presented in related environmental documentation.

Table 7-6. Effects on Groundwater Resources from the Plans, Policies, and Programs for the No Action Alternative as Compared to Existing Conditions

Agency	Program/Project	Status	Description of Program/Project	Effects on Groundwater Resources
California Department of Water Resources	Mayberry Farms Subsidence Reversal and Carbon Sequestration Project	Completed October 2010.	Permanently flood 308-acre parcel of DWR-owned land (Hunting Club leased) and restore 274 acres of palustrine emergent wetlands within Sherman Island to create permanent wetlands and to monitor waterfowl, water quality, and greenhouse gases.	No adverse effects on groundwater resources are anticipated (Bureau of Reclamation District 341 2009).
Contra Costa Water District	Contra Costa Canal Fish Screen Project (Rock Slough)	Under construction as of July 2011.	Installation of a fish screen at Rock Slough Intake.	No adverse effects on groundwater resources are anticipated due to implementation of mitigation measures.

Agency	Program/Project	Status	Description of Program/Project	Effects on Groundwater Resources
Contra Costa Water District, Bureau of Reclamation, and California Department of Water Resources	Middle River Intake and Pump Station (previously known as the Alternative Intake Pump Station)	Project completed and formally dedicated July 20, 2010.	This project includes a potable water intake and pump station to improve drinking water quality for Contra Costa Water District customers.	No adverse effects on groundwater resources are anticipated (Contra Costa Water District 2006).
California Department of Water Resources	Federal Energy Regulatory Commission License Renewal for Oroville Project	Draft Water Quality Certification issued December 6, 2010 and comments on Draft received December 10, 2010.	The renewed federal license will allow the Oroville Facilities to continue providing hydroelectric power and regulatory compliance with water supply and flood control.	No adverse effects on groundwater resources are anticipated (California Department of Water Resources 2008).
Freeport Regional Water Authority and Bureau of Reclamation	Freeport Regional Water Project	Project was completed late 2010.	Project includes an intake/pumping plant near Freeport on the Sacramento River and a conveyance structure to transport water through Sacramento County to the Folsom South Canal.	No adverse effects on groundwater resources are anticipated (Freeport Regional Water Authority 2003).
California Department of Water Resources and Solano County Water Agency	North Bay Aqueduct Alternative Intake Project		This project will construct an alternative intake on the Sacramento River and a new segment of pipeline to connect it to the North Bay Aqueduct system.	No adverse effects on groundwater are anticipated.
Reclamation District 2093	Liberty Island Conservation Bank		This project includes the restoration of inaccessible, flood-prone land, zoned as agriculture but not actively farmed, to area enhancement of wildlife resources.	No adverse effects on groundwater resources are anticipated (Bureau of Reclamation District 2093 2009).
City of Stockton	Delta Water Supply Project (Phase 1)	The project is currently under construction.	This project consists of a new intake structure and pumping station adjacent to the San Joaquin River; a water treatment plant along Lower Sacramento Road; and water pipelines along Eight Mile, Davis, and Lower Sacramento Roads.	No adverse effects on groundwater are anticipated due to implementation of mitigation measures (City of Stockton 2005).
Bureau of Reclamation and State Water Resources Control Board	Battle Creek Salmon and Steelhead Restoration Project	Project is ongoing.	This project includes restoration of approximately 48 miles of habitat in Battle Creek and its tributaries to improve passage, growth, and recovery for anadromous fish populations.	No adverse effects on groundwater resources are anticipated (Bureau of Reclamation 2005).

Agency	Program/Project	Status	Description of Program/Project	Effects on Groundwater Resources
Tehama Colusa Canal Authority and Bureau of Reclamation	Red Bluff Diversion Dam Fish Passage Project	Expected completion in 2012.	Proposed improvements include modifications made to upstream and downstream anadromous fish passage and water delivery to agricultural lands within CVP.	No adverse effects on groundwater are anticipated (Bureau of Reclamation 2002).
Bureau of Reclamation, California Department of Fish and Wildlife, and Natomas Central Mutual Water Company	American Basin Fish Screen and Habitat Improvement Project		This three-phase project includes consolidation of diversion facilities; removal of decommissioned facilities; aquatic and riparian habitat restoration; and installation of fish screens in the Sacramento River. Total project footprint encompasses approximately 124 acres east of the Yolo Bypass.	No adverse effects on groundwater resources are anticipated (Bureau of Reclamation 2008a).
Bureau of Reclamation, U.S. Army Corps of Engineers, Sacramento Area Flood Control Agency, and Central Valley Flood Protection Board	Folsom Dam Safety and Flood Damage Reduction Project	Anticipated completion by 2016.	This project includes implementation of an auxiliary spillway, dam safety modifications, security and reduction improvements, and flood damage prevention.	No adverse effects on groundwater resources are anticipated due to implementation of mitigation measures (Bureau of Reclamation 2008b).
Bureau of Reclamation	Delta-Mendota Canal/California Aqueduct Intertie	Completed in 2012.	The purpose of the intertie is to better coordinate water delivery operations between the California Aqueduct (state) and the Delta-Mendota Canal (federal) and to provide better pumping capacity for the Jones Pumping Plant. New project facilities include a pipeline and pumping plant.	No adverse effects on groundwater are anticipated (Bureau of Reclamation 2009).
Yolo County	General Plan Update	General plan was adopted November 10, 2009.	Anticipated implementation of policies and programs such as the Farmland Conversion Mitigation Program would minimize conversion of agricultural land to nonagricultural uses through mitigation.	No adverse effects on groundwater resources are anticipated due to implementation of mitigation measures (Yolo County 2009).
Zone 7 Water Agency and California Department of Water Resources	South Bay Aqueduct Improvement and Enlargement Project	Project is ongoing.	The project includes construction of a new reservoir and pipelines and canals to increase the capacity of the South Bay Aqueduct.	No adverse effects on groundwater resources are anticipated due to implementation of mitigation measures (California Department of Water Resources 2004e).

Agency	Program/Project	Status	Description of Program/Project	Effects on Groundwater Resources
Bureau of Reclamation, San Luis & Delta Mendota Water Authority	Grassland Bypass Project, 2010–2019, and Agricultural Drainage Selenium Management Program	Program under development. Final EIS/EIR in 2009	Reduce effects from agricultural drainage on wildlife refuges and wetlands. Will convey subsurface agricultural drainage to Mud Slough (tributary of San Joaquin River) (Bureau of Reclamation and San Luis & Delta-Mendota Water Authority 2008)	Beneficial, neutral, or less-than-significant effects on subsurface agricultural drainage and shallow groundwater levels; beneficial effects on groundwater salinity

7.3.3.2 Alternative 1A—Dual Conveyance with Pipeline/Tunnel and Intakes 1–5 (15,000 cfs; Operational Scenario A)

Alternative 1A would result in temporary effects on lands and communities associated with construction of five intakes and intake pumping plants, and other associated facilities; two forebays; conveyance pipelines; and tunnels. Nearby areas would be altered as work or staging areas, concrete batch plants, fuel stations, or be used for spoils storage areas. Sites used temporarily for borrow and then for spoils would also be anticipated to have a temporary effect on lands and communities. Transmission lines, access roads, and other incidental facilities would also be needed for operation of the project and construction of these structures would have temporary effects on lands and communities.

The following impact analysis is divided into two subsections: (1) effects of construction and operation of facilities under CM1 and other conservation measures in the Delta Region, and (2) effects of operations of facilities under CM1 in the Export Service Areas.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

Construction of the conveyance facilities would require dewatering operations. The dewatering wells would be generally 75 to 300 feet deep, placed every 50 to 75 feet apart along the construction perimeter as needed, and each would pump 30–100 gpm. Dewatering for the tunnel shaft constitutes the deeper dewatering (300 feet deep) while the shallow (75 feet deep) dewatering is reserved for open trench construction; no dewatering is required along the tunnel alignment; and the 50–75 feet dewatering wells frequency distance applies to the pipelines, intakes, widened levees, the perimeter of the forebay embankments, the perimeter of excavation for the pumping plants, and the perimeter of tunnel shafts. Dewatering would occur 24 hours per day and 7 days per week and would be initiated 1 to 4 weeks prior to excavation. Dewatering would continue until excavation is completed and the construction site is protected from higher groundwater levels. Dewatering requirements of features along this alignment are assumed to range from approximately 240 to 10,500 gpm (California Department of Water Resources 2010b).

Groundwater removed with the dewatering system would be treated as necessary and discharged to surface waters under an NPDES permit. Velocity dissipation features, such as rock or grouted riprap, would be used to reduce velocity and energy and prevent scour. Dewatering facilities would be removed following construction activities.

NEPA Effects: Dewatering would temporarily lower groundwater levels in the vicinity of the dewatering sites. Two areas could be subject to substantial lowering of groundwater levels: (1) In the vicinity of the intake pump stations along the Sacramento River; and (2) in the vicinity of the Byron Tract Forebay. Groundwater-level lowering from construction dewatering activities is forecasted to be less than 10 feet in the vicinity of the intakes and less than 20 feet in the vicinity of the forebay. The horizontal distance from the boundary of the excavation to locations where forecasted groundwater levels are 5 feet below the static groundwater level is defined as the "radius of influence" herein. The radius of influence is forecasted to extend approximately 2,600 feet from the Byron Tract Forebay excavation and from the intake excavations (Figure 7-7). Groundwater would return to pre-pumping levels over the course of several months. Simulation results suggest that 2 months after pumping ceases, water levels would recover to within 5 feet of pre-pumping water levels. The sustainable yield of some wells might temporarily be affected by the lowering of water levels such that they are not able to support existing land uses. The construction of conveyance features could result in an adverse effect on groundwater levels and associated well yields that would be temporary. It should be noted that the forecasted impacts described above reflect a worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis.

CEQA Conclusion: Construction activities associated with conveyance facilities under CM1, including temporary dewatering and associated reduced groundwater levels, have the potential to temporarily affect the productivity of existing nearby water supply wells. Groundwater levels within 2,600 feet of the areas to be dewatered are anticipated to experience groundwater level reductions of up to 20 feet for the duration of the dewatering activities and up to 2 months after dewatering activities are completed. Nearby domestic and municipal wells could experience significant reductions in well yield, if they are shallow wells, and may not be able to support existing land uses. The temporary localized impact on groundwater levels and associated well yields is considered significant because construction-related dewatering might affect the amount of water supplied by shallow wells located near the CM1 construction sites. Mitigation Measure GW-1 identifies a monitoring procedure and options for maintaining an adequate water supply for land owners that experience a reduction in groundwater production from wells within 2,600 feet of construction-related dewatering activities. It should be noted that the forecasted impacts described above reflect a worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis. Implementing Mitigation Measure GW-1 would help address these effects; however, the impact may remain significant because replacement water supplies may not meet the preexisting demands or planned land use demands of the affected party. In some cases this impact might temporarily be significant and unavoidable until groundwater elevations recover to preconstruction conditions, which could require several months after dewatering operations cease.

Mitigation Measure GW-1: Maintain Water Supplies in Areas Affected by Construction Dewatering

Prior to construction, BDCP proponents will determine the location of wells within the anticipated area of influence of construction sites at which dewatering would occur. Based on available information, the location of wells, depths of the wells and the depth to groundwater within these wells will be determined. During construction dewatering, monitoring wells should be installed sufficiently close to the groundwater dewatering sites, or if possible, water levels in existing wells will be monitored, in order to be able to detect changes in water levels attributable to dewatering activities. If monitoring data or other substantial evidence indicates that groundwater levels have declined in a manner that could adversely affect adjacent wells, temporarily rendering the wells unable to provide adequate supply to meet preexisting demands or planned land use demands, the BDCP proponents will implement one or more of the following measures:

- Offset domestic water supply losses attributable to construction dewatering activities. The BDCP proponents will ensure domestic water supplies provided by wells are maintained during construction. Potential actions to offset these losses include installing sheet piles to depths below groundwater elevations, deepening or modifying wells used for domestic purposes to maintain water supplies at preconstruction levels, or securing potable water supplies from offsite sources. Offsite sources could include potable water transported from a permitted source or providing a temporary connection to nearby wells not adversely affected by dewatering.

- Offset agricultural water supply losses attributable to construction dewatering activities. The BDCP proponents will ensure agricultural water supplies are maintained during construction or provide compensation to offset for crop production losses. If feasible, the BDCP proponents will install sheet piles to depths below groundwater elevations, or deepen or modify the wells to ensure agricultural production supported by water supplied by these wells is maintained. If deepening or modifying existing wells is not feasible, the BDCP proponents will secure a temporary alternative water supply or compensate farmers for production losses attributable to a reduction in available groundwater supplies.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: The operation of Alternative 1A conveyance features is not anticipated to affect groundwater levels other than in the vicinity of the two new forebays: the Intermediate Forebay and the Byron Tract Forebay adjacent to the east side of Clifton Court. In the absence of design features intended to minimize seepage, groundwater levels are projected to rise by up to 10 feet in the vicinity of the Intermediate and Byron Tract Forebays due to groundwater recharge from these surface water impoundments (Figure 7-8). Were they to occur, these groundwater-level increases could potentially result in groundwater levels encroaching on the ground surface in the vicinity of the new forebays, and potentially result in impacts on agricultural operations in the vicinity. Impacts, design measures, and mitigation measures related to seepage are addressed in the discussions of Impacts GW-4 and GW-5 and related mitigation measures.

Groundwater level rises of 10 feet or more could occur in the vicinity of the Intermediate and Byron Tract forebays, which would not reduce yields of nearby wells. Operation of the tunnel would have no impact on existing wells or yields given these facilities would be located more than 100 feet underground and would not substantially alter groundwater levels in the vicinity. There would be no adverse effect under Alternative 1A.

CEQA Conclusion: Groundwater level rises of 10 feet or more could occur in the vicinity of the Intermediate and Byron Tract forebays, which would not reduce yields of nearby wells. Operation of the tunnel would have no impact on existing wells or yields given these facilities would be located over 100 feet underground and would not substantially alter groundwater levels in the vicinity.

Groundwater levels in the Suisun Marsh area under Alternative 1A are forecasted to rise by 1 to 5 feet compared with Existing Conditions (Figure 7-9). This groundwater level rise is primarily attributable to sea level rise and climate change conditions in the Alternative 1A CVHM-D simulation. However, the anticipated effects of climate change and sea level rise are provided for information purposes only and do not lead to mitigation measures. Therefore, this impact would be less than significant. No mitigation is required.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

NEPA Effects: Dewatering would temporarily lower groundwater levels and cause small changes in groundwater flow patterns near the intake pump stations along the Sacramento River, Intermediate Forebay, and Byron Tract Forebay. Groundwater would return to levels within 5 feet of the static condition about 2 months after dewatering activities cease. Since no significant regional changes in groundwater flow directions are forecasted, and the inducement of poor-quality groundwater into areas of better quality is unlikely, it is anticipated that there would be no change in groundwater quality for Alternative 1A (see Section 7.3.3).

Groundwater removed with the dewatering system would be treated as necessary and discharged to surface waters under an NPDES permit (see Chapter 8*, Water Quality*). Construction BMPs would also be implemented to minimize dewatering impacts to the extent practicable, as described in Appendix 3B. There would be no adverse effect.

CEQA Conclusion: No significant groundwater quality impacts are anticipated during construction activities. Because of the temporary and localized nature of construction dewatering, the potential for the inducement of the migration of poor-quality groundwater into areas of higher quality groundwater will be low. Further, the planned treatment of extracted groundwater prior to discharge into adjacent surface waters would prevent significant impacts on groundwater quality.

No significant groundwater quality impacts are anticipated in most areas of the Delta during the implementation of Alternative 1A, because changes to regional patterns of groundwater flow are not anticipated. However, degradation of groundwater quality near the Suisun Marsh area are likely, due to the effects of saline water intrusion caused by rising sea levels (see discussion under Impact GW-2). Effects due to climate change are provided for informational purposes only and do not lead to mitigation. This impact would be less than significant. No mitigation is required.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: In the absence of seepage cutoff walls intended to minimize local changes to groundwater flow, the lowering of groundwater levels due to construction dewatering would temporarily affect localized shallow groundwater flow patterns during and immediately after the construction dewatering period. In particular, nearby shallow groundwater would temporarily flow toward the construction dewatering sites. The radius of influence, as described above, provides a sense of the potential areal extent of the temporary change in shallow groundwater flow patterns. For the Byron Tract Forebay site, only a portion of the shallow groundwater flow will be directed inward toward the dewatering operations. Forecasted temporary changes in shallow groundwater flow directions and areas of impacts are minor near the intakes, as discussed in Impact GW-1. Therefore, agricultural drainage during construction of conveyance features is not forecasted to result in adverse effects under Alternative 1A. In some instances, the lowering of groundwater levels in areas that experience near-surface water level conditions (or near-saturated root zones) would be beneficial. There would be no adverse effect.

CEQA Conclusion: The forecasted changes in shallow groundwater flow patterns due to construction dewatering activities in the Delta are localized and temporary and are not anticipated to cause significant impacts on agricultural drainage. This impact would be less than significant. No mitigation is required.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: The Intermediate and Byron Tract Forebays would be constructed to comply with the requirements of the Division of Safety of Dams (DSD) which includes design provisions to minimize seepage under the embankments, such as cutoff walls. These design provisions would minimize seepage under the embankments and onto adjacent properties. Once constructed, the operation of the forebays would be monitored to ensure seepage does not exceed performance requirements. In the event seepage were to exceed these performance requirements, the BDCP proponents would modify the embankments or construct seepage collection systems that would ensure any seepage from the forebays would be collected and conveyed back to the forebay or other suitable disposal site.

However, operation of Alternative 1A would result in local changes in groundwater flow patterns adjacent to the Intermediate and Byron Tract forebays, where groundwater recharge from surface water would result in groundwater level increases. If agricultural drainage systems adjacent to these forebays are not adequate to accommodate the additional drainage requirements, operation of the forebays could interfere with agricultural drainage in the Delta.

CEQA Conclusion: The Intermediate and Byron Tract Forebay embankments would be constructed to DSD standards and the BDCP proponents would monitor the performance of the embankments to ensure seepage does not exceed performance requirements. In the event seepage would exceed DSD requirements, the BDCP proponents would modify the embankments or construct and operate seepage collection systems to ensure the performance of existing agricultural drainage systems would be maintained.

However, operation of Alternative 1A would result in local changes in shallow groundwater flow patterns in the vicinity of the Intermediate and Byron Tract forebays caused by recharge from surface water, and could cause significant impacts on agricultural drainage where existing systems are not adequate to accommodate the additional drainage requirements. Implementation of Mitigation Measure GW-5 is anticipated to reduce this impact to a less-than-significant level in most instances, though in some instances mitigation may be infeasible due to factors such as costs that would be imprudent to bear in light of the fair market value of the affected land. The impact is therefore significant and unavoidable as applied to such latter properties.

In addition, as described for Impact GW-2, groundwater levels are projected to increase in Suisun Marsh under Alternative 1A compared to Existing Conditions, primarily due to sea level rise and climate change conditions as simulated with the Alternative 1A CVHM-D run. These increases in groundwater levels could affect agricultural drainage in the Suisun Marsh area, but do not in and of themselves require mitigation.

Mitigation Measure GW-5: Agricultural Lands Seepage Minimization

Areas potentially subject to seepage caused by implementation of habitat restoration and enhancement actions or operation of water conveyance facilities shall be monitored and evaluated on a site-specific basis by BDCP proponents prior to the commencement of construction activities to identify baseline groundwater conditions. Restoration sites, along with the sites of water conveyance features that could result in seepage, shall be subsequently monitored once construction is completed. Monitoring shall include placement of piezometers and/or periodic field checks to assess local groundwater levels and associated impacts on agricultural field conditions. In areas where operation of water conveyance facilities or habitat restoration is determined to result in seepage impacts on adjacent parcels, potentially feasible additional mitigation measures will be developed in consultation with affected landowners. These measures may include installation or improvement of subsurface agricultural drainage or an equivalent drainage measure, as well as pumping to provide for suitable field conditions (groundwater levels near pre-project levels). Such measures shall ensure that the drainage characteristics of affected areas would be maintained to the level existing prior to project construction.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

NEPA Effects: Increased frequency of inundation of areas associated with the proposed tidal habitat, channel margin habitat, and seasonally inundated floodplain restoration actions would result in increased groundwater recharge. Such increased recharge could result in groundwater level rises in some areas. Depending on the local geology, flooding of one area could also increase seepage to adjacent islands. Seasonally inundated floodplain restoration actions proposed in the north, east, and south Delta areas would be expected to result in a substantially increased rate of recharge and related groundwater-level increases. The magnitude of these effects depends on existing groundwater levels and land uses. For example, in the central Delta and portions of the north and south Delta, areas that are below sea level would experience saturated soils. More frequent inundation would increase seepage, which is already difficult and expensive to control in most agricultural lands in the Delta (see Chapter 14, *Agricultural Resources*). Effects on agricultural drainage and potential effects would need to be addressed on a site-specific basis.

CEQA Conclusion: Increased frequency of inundation of areas associated with the proposed tidal habitat, channel margin habitat, and seasonally inundated floodplain restoration actions would result in increased groundwater recharge. Such increased recharge could result in groundwater level rises in some areas and would increase seepage, which is already difficult and expensive to control in most agricultural lands in the Delta (see Chapter 14, *Agricultural Resources*). This impact would be reduced to a less-than-significant level with the implementation of Mitigation Measure GW-5 by identifying areas where seepage conditions have worsened and installing additional subsurface drainage measures, as needed.

Implementation of Mitigation Measure GW-5 is anticipated to reduce this impact to a less-than-significant level in most instances, though in some instances mitigation may be infeasible due to factors such as costs. The impact is therefore significant and unavoidable as applied to such latter properties.

As described for Impact GW-2, groundwater levels are projected to increase in Suisun Marsh under Alternative 1A compared to Existing Conditions, primarily due to sea level rise and climate change conditions as simulated with the Alternative 1A CVHM-D run. These increases in groundwater levels could affect agricultural drainage in the Suisun Marsh area, but do not in and of themselves require mitigation.

Mitigation Measure GW-5: Agricultural Lands Seepage Minimization

See Mitigation Measure GW-5 under Impact GW-5.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

NEPA Effects: Implementation of other conservation measures under Alternative 1A is generally not anticipated to alter regional patterns of groundwater flow or quality. However, increased inundation frequency in restoration areas would increase the localized areas exposed to saline and brackish surface water, which could result in increased groundwater salinity beneath such areas. Potential effects would need to be addressed on a site-specific basis.

The flooding of large areas with saline or brackish water would result in an adverse effect on groundwater quality beneath or adjacent to flooded areas. It would not be possible to completely avoid this effect. However, if water supply wells in the vicinity of these areas are not useable because of water quality issues, Mitigation Measure GW-7 is available to address this effect.

CEQA Conclusion: At this point, a definitive conclusion regarding the potential for groundwater quality degradation beneath restoration areas cannot be reached. Potential impacts would need to be addressed on a site-specific basis, but are anticipated to be significant. Implementation of Mitigation Measure GW-7 would reduce this impact, but the impact would remain significant.

Mitigation Measure GW-7: Provide an Alternate Source of Water

For areas that will be on or adjacent to implemented restoration components, groundwater quality will be monitored by BDCP proponents prior to implementation to establish baseline groundwater quality conditions. Unacceptable degradation of groundwater quality will be determined by comparing post-implementation groundwater quality to relevant regulatory standards and with consideration of previously established beneficial uses. For wells affected by degradation in groundwater quality, water of a quality comparable to pre-project conditions would be provided. Options for replacing the water supply could include drilling an additional well or a deeper well to an aquifer zone with water quality comparable to or better than preconstruction conditions or replacement of potable water supply. Construction activities are anticipated to be localized and would not result in change in land uses. The well drilling activities would result in short-term noise impacts for several days. (Chapter 31 provides an assessment of the impacts of implementing proposed mitigation measures.)

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

Total long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 1A would be higher than under the No Action Alternative, as described in Chapter 5, *Water Supply* and Table 7-7.

NEPA Effects: Increases in surface water deliveries attributable to project operations from the implementation of Alternative 1A are anticipated to result in a corresponding decrease in groundwater use in the Export Service Areas as compared to the No Action Alternative.

Historically, groundwater resources were the only source of water supply in the Central Valley. The heavy use of groundwater has caused groundwater quality issues, drainage issues, groundwater overdraft, and land subsidence (as discussed in Section 7.1). Throughout many areas of the San Joaquin River and Tulare Lake watersheds, shallow groundwater is characterized by high salinity. Use of this groundwater for irrigation deposited salts along with agricultural chemicals (nutrients and fertilizers) in the upper soil layer. These constituents leached into the underlying shallow groundwater aquifers and caused them to be unsuitable for irrigation.

Table 7-7. Long-Term State Water Project and Central Valley Project Deliveries to Hydrologic Regions Located South of the Delta

	Long-Term Average State Water Project and Central Valley Project Deliveries (TAF/year)		
Alternative	San Joaquin and Tulare Hydrologic Region	Central Coast Hydrologic Region	Southern California Hydrologic Region
Existing Conditions	2,964	47	1,647
No Action Alternative	2,519	40	1,484
Alternative 1	3,070	51	1,853
Alternative 2	2,846	49	1,711
Alternative 3	3,023	50	1,821
Alternative 4 Scenario H1	2,949	49	1,784
Alternative 4 Scenario H2	2,767	40	1,491
Alternative 4 Scenario H3	2,781	48	1,668
Alternative 4 Scenario H4	2,610	39	1,370
Alternative 5	2,709	45	1,613
Alternative 6	2,285	34	1,136
Alternative 7	2,272	36	1,162
Alternative 8	2,069	27	803
Alternative 9	2,529	43	1,410

Surface water was provided though the CVP and SWP to provide irrigation water of higher quality than was available in local groundwater. The expanded use of surface water for irrigation has resulted in a reduction in the degree of groundwater overdraft of local groundwater basins. County ordinances and groundwater management plans also aim at reducing impacts on groundwater by various users (see Section 7.2). None of the groundwater basins in the Central Valley have been adjudicated.

Generally, when available, agricultural water users in the San Joaquin River and Tulare Lake areas prefer to use surface water for irrigation because the water quality is better than for groundwater. When adequate surface water is not available, they will use groundwater (U.S. Geological Survey 2009: 60). The CVHM uses the FMP process (see Section 7.3.1.1) to estimate agricultural water supply needs and assumes that when surface water deliveries are available, they are used first, before groundwater is pumped for additional water supplies.

CVHM modeling results show that groundwater levels would rise beneath the Corcoran Clay by up to 10 feet in most areas in the western portions of the San Joaquin and Tulare Basins, but could exceed 250 feet under WBS 14 (i.e., Westside and Northern Pleasant Valley basins) as compared to the No Action Alternative. The forecasted maximum groundwater level changes occur in August because agricultural groundwater pumping is typically highest during this month.

The forecasted groundwater level rises across the Export Service Areas during a typical peak groundwater level change condition in August, as compared to the No Action Alternative are shown in Figure 7-10. These forecasted changes in groundwater levels result from decreased agricultural pumping during the irrigation season due to an increase in surface water deliveries from the Delta under Alternative 1A in the western portion of the San Joaquin and Tulare Lake basins. Higher groundwater levels associated with reduced overall groundwater use would result in a beneficial effect.

Alternative 1A also is forecasted to increase the surface water supplies from the Delta to the Export Service Areas outside of the Central Valley. If more surface water is available for municipal, industrial, and agricultural users, utilization of groundwater resources will be reduced (see Chapter 5, *Water Supply*). Therefore, adverse effects on groundwater levels are not expected to occur due to the implementation of Alternative 1A in these areas.

Alternative 1A would result in a beneficial effect on groundwater levels in the Export Service Areas as compared with the No Action Alternative.

CEQA Conclusion: Groundwater levels would rise by up to 100 feet under WBS 14 (i.e., Westside and Northern Pleasant Valley basins) as compared to Existing Conditions. The forecasted maximum groundwater level changes occur in August because agricultural groundwater pumping is typically highest during this month.

The forecasted groundwater level rises across the Export Service Areas during a typical peak groundwater level change condition in August, as compared to Existing Conditions are shown in Figure 7-11.

On the eastern side of the San Joaquin and Tulare Lake basins, climate change impacts on stream flows could result in a decline in groundwater levels of up to 25 feet. In addition, if reduced stream flows are not adequate to meet the surface water diversion requirements, groundwater pumping could increase, resulting in a further decline in groundwater levels. However, impacts due to climate change would occur independently of the BDCP. The anticipated effects of climate change are provided for informational purposes only, but do not lead to mitigation measures.

Groundwater level rises associated with reduced overall groundwater use for Alternative 1A would be considered a beneficial impact for most of the Export Service Areas and thus would not adversely affect the yield of domestic, municipal and agricultural wells. No mitigation is required.

Impact GW-9: Degrade Groundwater Quality

NEPA Effects: Increases in surface water deliveries attributable to Alternative 1A operations are anticipated to result in a corresponding decrease in groundwater use in the Export Service Areas. The decreased groundwater use is not anticipated to alter regional patterns of groundwater flow or groundwater quality in the Export Service Areas. Therefore, there would be no adverse effect on groundwater quality in the Export Service Areas.

No change in groundwater quality is anticipated during construction activities because such activities would occur in the Delta Region outside of the Export Service Areas. There would be no adverse effect.

CEQA Conclusion: No significant groundwater quality impacts are anticipated during the implementation of Alternative 1A because it is not anticipated to alter regional groundwater flow patterns in the Export Service Areas. Therefore, this impact is considered less than significant. No mitigation is required.

Impact GW-10: Result in Groundwater Level-Induced Land Subsidence

NEPA Effects: Forecasted land subsidence estimates indicate that most of the Export Service Areas would see land subsidence of no more than a hundredth of an inch on average under Alternative 1A as compared with the No Action Alternative. Therefore, the potential for substantial land subsidence from groundwater pumping from implementation of Alternative 1A is low, and there would be no change in subsidence levels. There would be no adverse effects.

CEQA Conclusion: Forecasted land subsidence estimates indicate that most of the Export Service Areas would see land subsidence of no more than a hundredth of an inch on average under Alternative 1A as compared with Existing Conditions. Because the potential for land subsidence in the Export Service Areas is low, this impact is considered less than significant.

7.3.3.3 Alternative 1B—Dual Conveyance with East Alignment and Intakes 1–5 (15,000 cfs; Operational Scenario A)

Alternative 1B would result in potential effects on groundwater in the study area associated with construction of five intakes and intake pumping plants, one forebay, pipelines, canals, tunnels, siphons, an intermediate pumping plant, and other conservation measures. This alternative would differ from Alternative 1A primarily in that it would use a series of canals generally along the east section of the Delta to convey water from north to south, rather than long segments of deep tunnel through the central part of the Delta.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

Construction of the conveyance facilities would require dewatering operations. The dewatering wells would be generally 75 to 300 feet deep, placed every 50 to 75 feet apart along the construction perimeter as needed, and each would pump 30–100 gpm. Dewatering for the tunnel shaft constitutes the deeper dewatering (300 feet deep) while the shallow (75 feet deep) dewatering is reserved for open trench construction; no dewatering is required along the tunnel alignment; and the 50–75 feet dewatering wells frequency distance applies to the pipelines, intakes, widened levees, the perimeter of the forebay embankments, the perimeter of excavation for the pumping plants, and the perimeter of tunnel shafts. Dewatering would occur 24 hours per day and 7 days per week and would be initiated 1 to 4 weeks prior to excavation. Dewatering would continue until excavation is completed and the construction site is protected from higher groundwater levels. Dewatering requirements of features along this alignment are assumed to range from approximately 24,500 to 360,000 gpm (California Department of Water Resources 2010b).

Groundwater removed with the dewatering system would be treated as necessary and discharged to surface waters under an NPDES permit. Velocity dissipation features, such as rock or grouted riprap, would be used to reduce velocity and energy and prevent scour. Dewatering facilities would be removed following construction activities.

NEPA Effects: Dewatering would temporarily lower groundwater levels in the vicinity of the dewatering sites. Groundwater levels would decline in response to dewatering operations along the entire Eastern Canal alignment. Groundwater level impacts forecasted to occur along the canal during the middle stage construction period are shown in Figure 7-12a. Impacts along the central and southern portions of the canal alignment are anticipated to occur towards the end of the construction period and are shown in Figure 7-12b. Groundwater levels in the vicinity of the forebay would decline by up to 20 feet. Groundwater levels in the vicinity of the siphons and along the canal alignment are predicted to decline by up to approximately 10 to 15 feet. The horizontal distance from the boundary of the excavation to locations where drawdown is 5 feet below the static groundwater level, is defined as the "radius of influence." The radius of influence is forecasted to extend up to approximately 5,000 feet from the forebay, intake, siphon, and canal excavations. Impacts on groundwater levels would cease after approximately 3 months following the termination of dewatering activities at each excavation site. The sustainable yield of some wells might temporarily be affected by the lower water levels such that they are not able to support existing land uses. The construction of conveyance features would result in an adverse effect on groundwater levels and associated well yields that would be temporary. It should be noted that the forecasted impacts described above reflect worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis.

CEQA Conclusion: Construction activities under Alternative 1B including temporary dewatering and associated reduced groundwater levels have the potential to temporarily affect the productivity of existing nearby water supply wells. Groundwater levels within 5,000 feet of the areas to be dewatered are anticipated to experience groundwater level declines up to 20 feet for the duration of dewatering activities and up to 3 months after dewatering is completed. Nearby domestic and municipal wells located within this area could experience reductions in well yield, if they are shallow wells. The sustainable yield of some wells might temporarily be affected by the lower water levels such that they are not able to support the existing land uses. The temporary localized impact on groundwater levels and associated well yields would be significant because construction-related dewatering might affect the amount of water supplied by shallow wells located near the CM1 construction sites. Mitigation Measure GW-1 identifies a monitoring procedure and options for maintaining an adequate water supply for land owners that experience a reduction in groundwater production from wells within 5,000 feet of construction-related dewatering activities. It should be noted that the forecasted impacts described above reflect a worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis. Implementing Mitigation Measure GW-1 would help address these effects; however, the impact may remain significant because replacement water supplies may not meet the preexisting demands or planned land use demands of the affected party. In some cases this impact might temporarily be significant and unavoidable until groundwater elevations recover to preconstruction conditions, which could require several months after dewatering operations cease.

Mitigation Measure GW-1: Maintain Water Supplies in Areas Affected by Construction Dewatering

See Mitigation Measure GW-1 under Impact GW-1 in the discussion of Alternative 1A.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

When water levels in the canal are maintained below the elevation of the adjacent water table, groundwater will discharge from the aquifer into the canal system, and vice versa. However, the rate of groundwater and surface water interaction during operations will be different for the unlined and lined canal options due to differences in the permeability of the canal lining.

NEPA Effects:

Unlined Canal

For the unlined canal option, some groundwater recharge would occur episodically beneath the northern portion of the canal between the intakes and the Mokelumne River, resulting in a groundwater level rise of less than 5 feet, which would not adversely affect the yield of nearby supply wells. Groundwater discharge into the canal would occur along the middle portion of the canal between the Mokelumne River and the San Joaquin River. Forecasted groundwater level declines of approximately 10 feet would occur in this area, which could result in reduced yields of shallow supply wells located within 2 miles of the canal. Groundwater level declines of up to 10 feet are unlikely to affect the yields of deeper wells that may exist nearby. In the southern portion of the canal, between San Joaquin River and the Byron Tract Forebay, groundwater recharge from the canal would occur, thereby causing groundwater levels to rise up to 10 feet, which would not adversely affect the yield of nearby supply wells. In the absence of design features intended to minimize seepage, groundwater levels are also forecasted to rise up to 10 feet in the vicinity of the Byron Tract Forebay due to groundwater recharge from this surface water impoundment. Figure 7-13 presents the magnitude of groundwater elevation change during a typical peak groundwater level change condition. Simulations indicate that groundwater recharge from the southern portion of the canal could result in near-surface groundwater levels in localized areas. Impacts, design measures, and mitigation measures related to seepage are discussed in Impacts GW-4 and GW-5 and related mitigation measures.

Lined Canal

For the lined canal option, minimal changes of less than 1 foot would occur to groundwater levels in most areas in the vicinity of the canal due to the limited exchange of groundwater and surface water between the lined canal and the underlying groundwater aquifer. In the absence of design features intended to minimize seepage, modest groundwater level rises would occur in the vicinity of the Byron Tract Forebay (up to 10 feet), similar to the changes discussed under Alternative 1A, as shown in Figure 7-14. Groundwater discharge to the canal would occur along the middle portion of the canal between the Mokelumne River and the San Joaquin River. Forecasted groundwater level declines of less than 5 feet would occur in this area, and indicates potential reduction of shallow well yields within approximately 2 miles of the canal.

Unlined and Lined Canals

For both unlined and lined canal options, model simulations indicate up to 5 foot episodic lowering of groundwater levels beneath the Sacramento River within an approximately 4-mile wide corridor (about 2 miles on either side of the river) due to lower flows in the river as a result of diversions at the north Delta intakes that result in a reduction in river flows and elevations, as described in Chapter 6, *Surface Water*. For both the unlined and the lined canal option, the groundwater level changes would cause an adverse effect on nearby shallow domestic well yields.

CEQA Conclusion: For the unlined canal option, some groundwater recharge would occur episodically beneath the northern portion of the canal, between the intakes and the Mokelumne River. This results in a simulated groundwater level increase of less than 5 feet, which would not adversely affect the yield of nearby supply wells. Simulations further indicate that groundwater discharge would occur to the middle portion of the canal between the Mokelumne River and San Joaquin River. Forecasted groundwater level declines of approximately 10 feet could occur in this area, which could reduce the yields of shallow supply wells located within 2 miles of the canal (Figure 7-15). This impact would be significant for shallow wells near the canal where significant groundwater level declines occur. The sustainable yield of some wells might be affected by the lower water levels such that they are not able to support the existing or planned land uses for which permits have been granted. Implementation of Mitigation Measure GW-2 would help address these effects; however, the impact may continue to be significant because replacement water supplies may not meet the preexisting demands or planned land use demands of the affected party, as discussed for Impact GW-1 under Alternative 1A. Groundwater level declines of up to 10 feet are unlikely to affect the yields of nearby deeper wells. In the southern portion of the canal, between the San Joaquin River and the Byron Tract Forebay, groundwater recharge from the canal would occur and increase groundwater levels by up to 5 feet, which would not adversely affect the yield of nearby supply wells.

For the lined canal option, groundwater levels in the northern and southern portions of the canal would increase by less than 1 foot, which would not adversely affect the yield of nearby wells. Groundwater discharge to the canal would occur along the middle portion of the canal between the Mokelumne River and the San Joaquin River. Forecasted groundwater level declines of less than 5 feet would occur in this area, and indicates potential reduction of shallow well yields within approximately 2 miles of the canal (Figure 7-16). The sustainable yield of some wells might be affected by the lower water levels such that they are not able to support the existing or planned land uses for which permits have been granted. Implementation of Mitigation Measure GW-2 would help address these effects; however, the impact may continue to be significant because replacement water supplies may not meet the preexisting demands or planned land use demands of the affected party, as discussed for Impact GW-1 under Alternative 1A.

For both unlined and lined canal options, model simulations indicate up to 10-foot episodic lowering of groundwater levels beneath the Sacramento River within an approximately 2-mile wide corridor on either side of the river due to lower flows in the river as a result of diversions at the north Delta intakes that result in a reduction in river flows and elevations. Shallow wells in the vicinity of this corridor might see an episodic decrease in yields which might affect the existing or planned land-uses for which permits have been granted in this area. In the absence of design features intended to minimize seepage, modest groundwater level rises would occur in the vicinity of the Byron Tract Forebay (up to 10 feet), similar to the changes discussed under Alternative 1A.

Groundwater levels in the Suisun Marsh area under Alternative 1B are forecasted to rise by 1 to 5 feet compared with Existing Conditions. This groundwater level rise is primarily attributable to sea level rise and climate change conditions in the Alternative 1B CVHM-D simulation. However, the anticipated effects of climate change and sea level rise are provided for information purposes only and do not lead to mitigation measures.

Mitigation Measure GW-2: Maintain Water Supplies in Areas Affected by Changes in Groundwater Levels During Operation of Canals

See Mitigation Measure GW-1 for Impact GW-1 under Alternative 1A for applicable mitigations for this impact.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

NEPA Effects: Changes in groundwater flow patterns under Alternative 1B would be similar to those described for Alternative 1A. Groundwater dewatering activities along the canal alignment under Alternative 1B would occur on a wider area than dewatering activities along the tunnel alignment under Alternative 1A and might result in more extensive groundwater flow and quality disturbances than for Alternative 1A. However, regional groundwater flow patterns would remain unchanged by localized construction dewatering operations. Implementation of Alternative 1B is not anticipated to alter regional patterns of groundwater flow or quality. Therefore, there would be no change in groundwater quality and no adverse effect.

CEQA Conclusion: See the CEQA conclusion for Impact GW-3 under Alternative 1A. The impact would be less than significant.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: In the absence of seepage cutoff walls intended to minimize local changes to groundwater flow, the lowering of groundwater levels from construction dewatering under Alternative 1B would temporarily affect shallow groundwater flow patterns during and immediately after the construction dewatering period. In particular, nearby shallow groundwater would temporarily flow toward the construction dewatering sites. The radius of influence, as described above, provides a sense of the potential areal extent of the temporary change in shallow groundwater flow patterns. Shallow groundwater flow patterns would be temporarily inward toward dewatering sites with minor changes in groundwater flow directions near the intakes. Substantial localized changes in groundwater flow directions could occur in the vicinity of the canal alignment. These forecasted changes in shallow groundwater flow patterns are localized and temporary and are not anticipated to cause adverse effects on agricultural drainage.

CEQA Conclusion: Under Alternative 1B, the temporary lowering of groundwater levels from construction dewatering activities would temporarily affect shallow groundwater flow patterns during and immediately after the construction dewatering period. In particular, nearby shallow groundwater would temporarily flow toward the construction dewatering sites. Shallow groundwater flow patterns would be temporarily inward toward dewatering sites with minor changes in groundwater flow directions near the intakes. Substantial localized changes in groundwater flow directions could occur in the vicinity of the canal alignment. These forecasted changes in shallow groundwater flow patterns are localized and temporary and are not anticipated to cause significant impacts on agricultural drainage. Therefore, this impact is considered less than significant.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: Byron Tract Forebay would be constructed to comply with the requirements of the DSD which includes design provisions to minimize seepage under the embankments, such as cutoff walls. These design provisions would minimize seepage under the embankments and onto adjacent properties. Once constructed, the operation of the forebay would be monitored to ensure seepage does not exceed performance requirements. In the event seepage were to exceed these performance requirements, the BDCP proponents would modify the embankments or construct seepage collection systems that would ensure any seepage from the forebay would be collected and conveyed back to the forebay or other suitable disposal site. However, local changes in groundwater flow patterns adjacent to the Byron Tract Forebay might occur due to groundwater recharge from surface water impoundment and would result in groundwater level increases. If agricultural drainage systems adjacent to this forebay are not adequate to accommodate the additional drainage requirements, operation of the forebay could interfere with agricultural drainage in the Delta under Alternative 1B.

Implementation of Alternative 1B with an unlined canal would result in local changes in groundwater flow patterns in the vicinity of the unlined canal alignment, where recharge to and discharge from the groundwater system would occur, resulting in groundwater level increases. The middle portion of the unlined canal is forecasted to gain groundwater from the east and west sides. This suggests that groundwater flow directions on the west side of the middle portion of the unlined canal would be altered from their prior east-west direction. Because groundwater would flow into the unlined canal, the potential exists to improve agricultural drainage in this area.

The lower portion of the unlined canal is situated in an area of the Delta that lies at or below sea level and existing land uses rely on drainage systems. Groundwater levels in this area are forecasted to increase due to leakage from the unlined canal, which would affect agricultural drainage. Operation of the unlined canal would cause an adverse effect on agricultural drainage that would be addressed by Mitigation Measure GW-5.

For the lined canal option, minimal changes to groundwater levels would occur in relation to canal operation due to the limited quantity of groundwater recharge from the lined canal or discharge from groundwater to the lined canal, as described under Impact GW-2 for Alternative 1B. However, implementation of Alternative 1B would result in local changes in groundwater flow patterns adjacent to the Byron Tract Forebay (as discussed above).

CEQA Conclusion: The forebay embankment would be constructed to DSD standards and the BDCP proponents would monitor the performance of the embankments to ensure seepage does not exceed performance requirements. In the event seepage would exceed DSD requirements, the BDCP proponents would modify the embankments or construct and operate seepage collection systems to ensure the performance of existing agricultural drainage systems would be maintained. However, local changes in groundwater flow patterns adjacent to the Byron Tract Forebay might occur due to groundwater recharge from surface water impoundment and would result in groundwater level increases. If agricultural drainage systems adjacent to this forebay are not adequate to accommodate the additional drainage requirements, operation of the forebay could cause significant impacts on agricultural drainage. Implementation of Mitigation Measure GW-5 is anticipated to reduce this impact to a less-than-significant level in most instances, though in some instances mitigation may be infeasible due to factors such as costs that would be imprudent to bear in light of the fair market value of the affected land. The impact is therefore significant and unavoidable as applied to such latter properties.

Implementation of Alternative 1B with the unlined canal would result in local changes in shallow groundwater flow patterns in the vicinity of the unlined canal alignment, and could cause significant impacts on agricultural drainage where systems are not adequate to accommodate the additional drainage requirements. Implementation of Mitigation Measure GW-5 is anticipated to reduce this impact in most instances. Occasionally, however, mitigation may be determined infeasible and the impact is therefore considered significant and unavoidable.

For the lined canal option, implementation of Alternative 1B would result in minimal changes to groundwater levels due to the limited quantity of groundwater recharge from the lined canal or discharge from groundwater to the lined canal. This impact is considered less than significant in the vicinity of the lined canal.

Groundwater levels in the Suisun Marsh area under Alternative 1B are forecasted to rise by 1 to 5 feet compared with Existing Conditions, which could lead to impacts on agricultural drainage. This groundwater level rise is primarily attributable to sea level rise and climate change conditions in the Alternative 1B CVHM-D simulation. However, the anticipated effects of climate change and sea level rise are provided for information purposes only and do not lead to mitigation measures.

Mitigation Measure GW-5: Agricultural Lands Seepage Minimization

Please see Mitigation Measure GW-5 under Impact GW-5 in the discussion of Alternative 1A.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 1B would be identical to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 1B would be identical to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-8 under Alternative 1A; project operations under Alternative 1B would be identical to those under Alternative 1A.

Impact GW-9: Degrade Groundwater Quality

See Impact GW-9 under Alternative 1A; project operations under Alternative 1B would be identical to those under Alternative 1A.

Impact GW-10: Result in Groundwater Level–Induced Land Subsidence

See Impact GW-10 under Alternative 1A; project operations of under Alternative 1B would be identical to those under Alternative 1A.

7.3.3.4 Alternative 1C—Dual Conveyance with West Alignment and Intakes W1–W5 (15,000 cfs; Operational Scenario A)

Alternative 1C would result in effects on groundwater in the study area associated with construction of five intakes and intake pumping plants, one forebay, conveyance pipelines, canals, a tunnel, culvert siphons, an intermediate pumping plant, and other conservation measures. This alternative would differ from Alternative 1A primarily in its use of a series of canals generally along the west section of the Delta to convey water from north to south, with a tunnel under a portion of the western Delta and the San Joaquin River rather than long segments of deep tunnel through the central part of the Delta.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

Construction of the conveyance facilities would require dewatering operations. The dewatering wells would be generally 75 to 300 feet deep, placed every 50 to 75 feet apart, and would each pump 30–100 gpm. Dewatering for the tunnel shaft constitutes the deeper dewatering (300 feet deep) while the shallow (75 feet deep) dewatering is reserved for open trench construction; no dewatering is required along the tunnel alignment; and the 50-75 feet dewatering wells frequency distance applies to the pipelines, intakes, widened levees, the perimeter of the forebay embankments, the perimeter of excavation for the pumping plants, and the perimeter of tunnel shafts. Dewatering would occur 24 hours per day and 7 days per week and would be initiated 1 to 4 weeks prior to excavation and continue until excavation is completed and the construction site is protected from higher groundwater. Dewatering requirements of features along this alignment are assumed to range from approximately 49,000 to 313,000 gpm (California Department of Water Resources 2010b).

Groundwater removed with the dewatering system would be treated as necessary and discharged to surface waters under an NPDES permit. Velocity dissipation features, such as rock or grouted riprap, would be used to reduce velocity and energy and prevent scour. Dewatering facilities would be removed following construction.

NEPA Effects: Dewatering would temporarily lower groundwater levels in the vicinity of the dewatering sites. Groundwater levels would decline in response to dewatering operations along the entire Western Canal alignment. The construction of the tunnel portion of this alignment would not require dewatering.

Groundwater level impacts predicted to occur along the northern and southern portions of the alignment during construction activities are shown in Figure 7-17. Groundwater levels in the vicinity of the intakes and the forebay would decline by up to 20 feet. Groundwater levels in the vicinity of the siphons and along the canal alignment are predicted to decline by approximately 10 to 15 feet. The horizontal distance from the boundary of the excavation to locations where forecasted groundwater levels are 5 feet below the static groundwater level is defined as the "radius of influence." The radius of influence would extend approximately up to 5,000 feet from the forebay, intake, siphon and canal excavations. Effects on groundwater levels would cease after approximately 3 months following the termination of dewatering activities at each excavation site. The sustainable yield of some wells might temporarily be affected by the lower water levels such that they are not able to support existing land uses. The construction of conveyance features would result in an adverse effect on groundwater levels and associated well yields that would be temporary. It should be noted that the forecasted impacts described above reflect a worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis.

CEQA Conclusion: Construction activities under Alternative 1C including temporary dewatering and associated reduced groundwater levels have the potential to temporarily affect the productivity of existing nearby water supply wells. Groundwater levels within 5,000 feet of the areas to be dewatered are anticipated to experience groundwater level reductions of up to 20 feet for the dewatering activities and up to 3 months after dewatering is completed. Shallow domestic and municipal wells located within this area could experience reductions in well yield. The sustainable yield of some wells might temporarily be affected by the lower water levels such that they are not able to support existing land uses. The temporary localized impact on groundwater levels and associated well yields would be significant because construction-related dewatering might affect the amount of water supplied by shallow wells located near the CM1 construction sites. Mitigation Measure GW-1 identifies a monitoring procedure and options for maintaining an adequate water supply for land owners that experience a reduction in groundwater production from wells within 5,000 feet of construction-related dewatering activities. It should be noted that the forecasted impacts described above reflect a worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis. Implementing Mitigation Measure GW-1 would help address these effects; however, the impact may remain significant because replacement water supplies may not meet the preexisting demands or planned land use demands of the affected party. In some cases this impact might temporarily be significant and unavoidable until groundwater elevations recover to preconstruction conditions, which could require several months after dewatering operations cease.

Mitigation Measure GW-1: Maintain Water Supplies in Areas Affected by Construction Dewatering

See Mitigation Measure GW-1 under Impact GW-1 in the discussion of Alternative 1A.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects:

Unlined Canal

For the unlined canal option, most canal leakage would occur in the northern portion of the canal, between the intakes and the inflow to the tunnel. Thus, rises in groundwater levels are forecasted to occur in these areas of the north Delta (up to 10 feet), which would not reduce the yields of nearby wells. This water level rise is not anticipated to adversely affect groundwater recharge.

No substantial effect on groundwater levels would be anticipated in the vicinity of the tunnel.

In the canal segment south of the tunnel, an area of groundwater recharge from the unlined canal would occur in an area that transitions to a zone of groundwater discharge to the canal in the vicinity of Byron Tract. This pattern of groundwater recharge and discharge results from the hydraulic grade line of the canal being above the groundwater table just south of the tunnel and transitioning to a condition where the hydraulic grade line falls below the groundwater water table further south. The effects on groundwater levels would be less than 5 feet throughout this area. In the absence of design features intended to minimize seepage, modest groundwater level rises would occur in the vicinity of the Byron Tract Forebay (up to 10 feet). The magnitude of groundwater elevation change during a typical peak water level change condition is shown in Figure 7-18. No substantial effect on groundwater levels are indicated in the vicinity of the tunnel. In the southern portion of the canal near Byron Tract, yields of nearby shallow wells could be reduced.

Lined Canal

For the lined canal option, minimal changes to groundwater levels would occur due to the limited quantity of groundwater recharge from the lined canal reaches or discharge from groundwater to the lined canal, as shown in Figure 7-19. In the absence of design features intended to minimize seepage, modest groundwater level rises in the vicinity of the Byron Tract Forebay (up to 10 feet), similar to the changes discussed under Alternative 1A. No substantial effect on groundwater levels is indicated in the vicinity of the tunnel. In the southern portion of the canal, simulation results indicate that groundwater levels would occasionally decline less than 5 feet throughout the alignment, which could reduce yields of nearby shallow wells.

Unlined and Lined Canals

For both unlined and lined canal options, groundwater levels would decline along the Sacramento River, as described under Alternative 1B.

For both canal options, the groundwater level changes could cause an adverse effect on nearby shallow domestic well yields. The sustainable yield of some wells might be affected by the lower water levels such that they are not able to support the existing or planned land uses for which permits have been granted.

CEQA Conclusion: For the unlined canal option under Alternative 1C, groundwater levels in the northern portion of the canal would increase by less than 10 feet, which would not reduce the yields of nearby wells. No substantial impact on groundwater levels is indicated in the vicinity of the tunnel. Along the unlined canal located south of the tunnel section, an area of groundwater recharge from the unlined canal would occur and would transition to a zone of groundwater discharge to the unlined canal in the vicinity of Byron Tract (Figure 7-20). The forecasted impacts on groundwater levels are less than 5 feet throughout the southern alignment of the unlined canal. In the southern portion of the unlined canal near Byron Tract, yields of nearby shallow wells could be reduced, which might affect the sustainability of existing or planned land uses for which permits have been granted and that use water from these wells.

For the lined canal option, minimal changes to groundwater levels would occur due to the limited quantity of groundwater recharge from the lined canal reaches or discharge from groundwater to the lined canal, as shown in Figure 7-21. In the absence of design features intended to minimize seepage, modest groundwater level rises in the vicinity of the Byron Tract Forebay (up to 10 feet), similar to the changes discussed under Alternative 1A. No substantial effect on groundwater levels is indicated in the vicinity of the tunnel. In the southern portion of the canal, simulation results indicate that groundwater levels would occasionally decline less than 5 feet throughout the alignment, which could reduce yields of nearby shallow wells.

For both the lined and the unlined canal option, the impact on well yields could be significant in areas near the southern portion of the canal. Implementation of Mitigation Measure GW-2 would help address these effects; however, the impact may continue to be significant because replacement water supplies may not meet the preexisting demands or planned land use demands of the affected party, as discussed for Impact GW-1 under Alternative 1A. In the absence of design features intended to minimize seepage, modest groundwater level rises in the vicinity of the Byron Tract Forebay (up to 10 feet), similar to the changes discussed under Alternative 1A.

Groundwater levels in the Suisun Marsh area under Alternative 1C are forecasted to rise by 1 to 5 feet compared with Existing Conditions. This groundwater level rise is primarily attributable to sea level rise and climate change conditions in the Alternative 1C CVHM-D simulation. However, the anticipated effects of climate change and sea level rise are provided for information purposes only and do not lead to mitigation measures.

Mitigation Measure GW-2: Maintain Water Supplies in Areas Affected by Changes in Groundwater Levels During Operation of Canals

Please see Mitigation Measure GW-1 under Impact GW-1 in the discussion of Alternative 1A.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 for Alternative 1B.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: In the absence of seepage cutoff walls intended to minimize local changes to groundwater flow, the lowering of groundwater levels from construction dewatering under Alternative 1C would temporarily affect shallow groundwater flow patterns during and immediately after the construction dewatering period. In particular, nearby shallow groundwater would temporarily flow toward the construction dewatering sites. The radius of influence, as described above, provides a sense of the potential areal extent of the temporary change in shallow groundwater flow patterns. Shallow groundwater flow patterns would be temporarily inward toward dewatering sites, compared with the No Action Alternative. Therefore, this effect would not be adverse.

CEQA Conclusion: Under Alternative 1C, the temporary lowering of groundwater levels from dewatering activities would temporarily affect localized and shallow groundwater flow patterns during and immediately after the construction dewatering period. In particular, nearby and shallow groundwater would flow toward the construction dewatering sites. The radius of influence provides a sense of the potential areal extent of the temporary change in shallow groundwater flow patterns. Groundwater flow patterns would not change substantially at the Byron Tract Forebay site and only small changes in flow direction at the intakes would occur. These forecasted changes in shallow groundwater flow patterns are localized and temporary. Therefore, this impact is considered less than significant.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: Implementation of Alternative 1C with an unlined canal would result in local changes in groundwater flow patterns adjacent to the unlined canal, where groundwater recharge from surface water would result in groundwater level increases. The upper portion of the unlined canal, between the Sacramento River intakes and the transition to the tunnel, would lose water to the surrounding groundwater, which would affect agricultural drainage in the area. Operations of the unlined canal would cause an adverse effect on agricultural drainage. Mitigation Measure GW-5 is available to address this effect.

For the lined canal option, minimal changes to groundwater levels would occur due to the limited quantity of groundwater recharge from the lined canal or discharge from groundwater to the lined canal, as described under Impact GW-2 for Alternative 1C. However, implementation of Alternative 1C would result in local changes in groundwater flow patterns adjacent to the Byron Tract Forebay.

The Byron Tract Forebay would be constructed to comply with the requirements of the DSD which includes design provisions to minimize seepage under the embankments, such as cutoff walls. These design provisions would minimize seepage under the embankments and onto adjacent properties. Once constructed, the operation of the forebay would be monitored to ensure seepage does not exceed performance requirements. In the event seepage were to exceed these performance requirements, the BDCP proponents would modify the embankments or construct seepage collection systems that would ensure any seepage from the forebay would be collected and conveyed back to the forebay or other suitable disposal site.

However, local changes in groundwater flow patterns adjacent to the Byron Tract Forebay might occur due to groundwater recharge from surface water impoundment and would result in groundwater level increases. If agricultural drainage systems adjacent to this forebay are not adequate to accommodate the additional drainage requirements, operation of the forebay could interfere with agricultural drainage in the Delta.

CEQA Conclusion: The Byron Tract Forebay embankments would be constructed to DSD standards and the BDCP proponents would monitor the performance of the embankments to ensure seepage does not exceed performance requirements. In the event seepage would exceed DSD requirements, the BDCP proponents would modify the embankments or construct and operate seepage collection systems to ensure the performance of existing agricultural drainage systems would be maintained. However, local changes in groundwater flow patterns adjacent to the Byron Tract Forebay might occur due to groundwater recharge from surface water impoundment and would result in groundwater level increases. If agricultural drainage systems adjacent to this forebay are not adequate to accommodate the additional drainage requirements, operation of the forebay could cause significant impacts on agricultural drainage. Implementation of Mitigation Measure GW-5 is anticipated to reduce this impact to a less-than-significant level in most instances, though in some instances mitigation may be infeasible due to factors such as costs that would be imprudent to bear in light of the fair market value of the affected land. The impact is therefore significant and unavoidable as applied to such latter properties.

The implementation of Alternative 1C would result in local changes in shallow groundwater flow patterns in the vicinity of the unlined canal alignment, and could cause significant impacts on agricultural drainage where systems are not adequate to accommodate the additional drainage requirements. This impact is considered significant. Implementation of Mitigation Measure GW-5 is anticipated to reduce this impact in most instances. Occasionally, however, mitigation may be determined infeasible and the impact is therefore considered significant and unavoidable.

For the lined canal option, minimal changes to groundwater levels would occur in the proximity of the canal due to the limited quantity of groundwater recharge from the lined canal or discharge from groundwater to the lined canal. Impact GW-5 would be considered less than significant in the vicinity of the lined canal.

Groundwater levels in the Suisun Marsh area under Alternative 1C are forecasted to rise by 1 to 5 feet compared with Existing Conditions, which could lead to impacts on agricultural drainage. This groundwater level rise is primarily attributable to sea level rise and climate change conditions in the Alternative 1C CVHM-D simulation. However, the anticipated effects of climate change and sea level rise are provided for information purposes only and do not lead to mitigation measures.

Mitigation Measure GW-5: Agricultural Lands Seepage Minimization

Please see Mitigation Measure GW-5 under Impact GW-5 in the discussion of Alternative 1A.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 1C would be identical to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 1C would be identical to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-8 under Alternative 1A; project operations under Alternative 1C would be identical to those under Alternative 1A.

Impact GW-9: Degrade Groundwater Quality

See Impact GW-9 under Alternative 1A; project operations under Alternative 1C would be identical to those under Alternative 1A.

Impact GW-10: Result in Groundwater Level-Induced Land Subsidence

See Impact GW-10 under Alternative 1A; project operations under Alternative 1C would be identical to those under Alternative 1A.

7.3.3.5 Alternative 2A—Dual Conveyance with Pipeline/Tunnel and Five Intakes (15,000 cfs; Operational Scenario B)

Facilities construction under Alternative 2A would be identical to those described for Alternative 1A. Alternative 2A would involve relocation of two of the intakes to a location south of the confluence of Sutter and Steamboat sloughs and the Sacramento River.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1A; construction activities under Alternative 2A would result in impacts similar to those under Alternative 1A. The only difference between Alternative 1A and Alternative 2A would be associated with the location of the intakes. Both alternatives use intakes 1, 2, and 3. However, Alternative 2A uses intakes 6 and 7 as opposed to intakes 4 and 5 for Alternative 1A.

NEPA Effects: Dewatering would temporarily lower groundwater levels in the vicinity of the dewatering sites. Three areas could be subject to substantial lowering of groundwater levels: (1) In the vicinity of intake pump stations 1, 2, and 3; (2) in the vicinity of intake pump stations 6 and 7; and (3) in the vicinity of Byron Tract Forebay. Groundwater-level lowering from construction dewatering activities is forecasted to be less than 10 feet in the vicinity of the intakes and less than 20 feet in the vicinity of the forebay. The horizontal distance from the boundary of the excavation to locations where forecasted groundwater levels are 5 feet below the static groundwater level is defined as the “radius of influence” herein. The radius of influence is forecasted to extend approximately 2,600 feet from the Byron Tract Forebay excavation and from the intake 1, 2, and 3 excavations and approximately 1,300 feet from the intake 6 and 7 excavations (Figure 7-22). Groundwater levels in the area of intakes 6 and 7 are deeper than in the area for intakes 1, 2, and 3; therefore less groundwater needs to be pumped for construction dewatering purposes.

Groundwater would return to pre-pumping levels over the course of several months. Simulation results suggest that two months after pumping ceases, water levels would be within 5 feet of pre-pumping water levels. The sustainable yield of some wells might temporarily be affected by the lower water levels such that they are not able to support existing land uses. The construction of conveyance features would result in an adverse effect on groundwater levels and associated well yields that would be temporary. It should be noted that the forecasted impacts described above reflect a worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis.

CEQA Conclusion: Construction activities associated with conveyance facilities under CM1 for Alternative 2A including temporary dewatering and associated reduced groundwater levels have the potential to temporarily affect the productivity of existing nearby water supply wells. Groundwater levels within 1,300 to 2,600 feet of the areas to be dewatered are anticipated to experience groundwater level reductions of less than 20 feet for the duration of the dewatering activities and up to 2 months after dewatering is completed. Nearby domestic and municipal wells could experience significant reductions in well yield, if they are shallow wells and may not be able to support existing land uses. The temporary localized impact on groundwater levels and associated well yields could be significant because construction-related dewatering might affect the amount of water supplied by shallow wells located near the CM1 construction sites. Mitigation Measure GW-1 identifies a monitoring procedure and options for maintaining an adequate water supply for land owners that experience a reduction in groundwater production from wells within the anticipated area of influence of construction-related dewatering activities. It should be noted that the forecasted impacts described above reflect a worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis. Implementing Mitigation Measure GW-1 would help address these effects; however, the impact may remain significant because replacement water supplies may not meet the preexisting demands or planned land use demands of the affected party. In some cases this impact might temporarily be significant and unavoidable until groundwater elevations recover to preconstruction conditions, which could require several months after dewatering operations cease.

Mitigation Measure GW-1: Maintain Water Supplies in Areas Affected by Construction Dewatering

See Mitigation Measure GW-1 under Impact GW-1 in the discussion of Alternative 1A.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1A; operations activities under Alternative 2A would result in impacts similar to those under Alternative 1A. Both alternatives use the same forebay locations, which, in the absence of design features intended to minimize seepage, would be the main locations of potential effects on groundwater levels and associated well yields.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1A; construction and operations activities under Alternative 2A would result in effects similar to those under Alternative 1A.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: See Impact GW-4 under Alternative 1A; construction activities under Alternative 2A would result in effects similar to those under Alternative 1A. The only difference between Alternative 1A and Alternative 2A would be associated with the location of the intakes. Alternative 2A uses intakes 6 and 7 as opposed to intakes 4 and 5 for Alternative 1A.

The lowering of groundwater levels due to construction dewatering would temporarily affect localized shallow groundwater flow patterns during and immediately after the construction dewatering period. In particular, nearby shallow groundwater would temporarily flow toward the construction dewatering sites. The radius of influence, as described above, provides a sense of the potential areal extent of the temporary change in shallow groundwater flow patterns. For the Byron Tract Forebay site, only a portion of the shallow groundwater flow will be directed inward toward the dewatering operations. Forecasted temporary changes in shallow groundwater flow directions and areas of impacts are minor near the intakes, as discussed in Impact GW-1. Therefore, agricultural drainage during construction of conveyance features is forecasted to result in no change under Alternative 2A. In some instances, the lowering of groundwater levels in areas that experience near-surface water level conditions (or near-saturated root zones) would be beneficial. There would be no adverse effect.

CEQA Conclusion: The forecasted changes in shallow groundwater flow patterns due to construction dewatering activities in the Delta are localized and temporary and are not anticipated to cause significant impacts on agricultural drainage. This impact would be less than significant. No mitigation is required.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1A; operations activities under Alternative 2A would result in effects similar to those under Alternative 1A.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 2A would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 2A would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: Total long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 2A would be higher than under the No Action Alternative, as described in Chapter 5, *Water Supply* and Table 7-7. Increases in surface water deliveries attributable to project operations from the implementation of Alternative 2A are anticipated to result in a corresponding decrease in groundwater use in the Export Service Areas compared to the No Action Alternative, as discussed in Section 7.3.3.2.

CVHM modeling results show that groundwater levels would rise beneath the Corcoran Clay of up to 10 feet in most areas in the western and southern portions of the Valley, but could exceed 250 feet under WBS 14 (i.e., Westside and Northern Pleasant Valley basins of the western Tulare Basin) as compared with the No Action Alternative. The forecasted maximum groundwater level changes occur in August because agricultural groundwater pumping is typically highest during this month. These forecast changes in groundwater levels, as shown in Figure 7-23, result from decreased agricultural pumping during the irrigation season due to an increase in surface water deliveries from the Delta under Alternative 2A in the western portion of the San Joaquin and Tulare Lake basins. Higher groundwater levels associated with reduced overall groundwater use would result in a beneficial effect.

The SWP deliveries to areas outside of the Central Valley under this alternative would be greater than those under the No Action Alternative. If more SWP/CVP surface water is available, utilization of groundwater resources could be reduced. Implementation of Alternative 2A would result in an overall decrease in groundwater pumping and a corresponding increase in groundwater levels. Therefore, adverse effects on groundwater levels are not expected to occur due to the implementation of Alternative 2A in these areas.

CEQA Conclusion: Total long-term average annual surface water deliveries to the CVP and SWP Service Areas under Alternative 2A would be less than under Existing Conditions in the San Joaquin and Tulare export service areas, largely because of effects due to climate change, sea level rise, and increased water demand north of the Delta. As a result, modeling predicts that groundwater pumping under Alternative 2A would be greater than under Existing Conditions, and that groundwater levels in some areas would be lower than under Existing Conditions.

CVHM modeling results show that groundwater levels would decrease by up to 250 feet beneath the Corcoran Clay under WBS14 (i.e., Westside and Northern Pleasant Valley basins) as compared with Existing Conditions. The forecasted groundwater level changes across the Export Service Areas during a typical peak groundwater level change condition in August as compared to Existing Conditions are shown in Figure 7-24. These forecasted changes in groundwater levels result from increased agricultural pumping during the irrigation season due to a decrease in surface water deliveries from the Delta under Alternative 2A in the western portion of the San Joaquin and Tulare Lake basins. On the eastern side of the San Joaquin and Tulare Lake basins, climate change impacts on stream flows could result in a decline in groundwater levels of up to 50 feet. In addition, if reduced stream flows are not adequate to meet the surface water diversion requirements, groundwater pumping could increase, resulting in a further decline in groundwater levels.

As shown above in the NEPA analysis, SWP and CVP deliveries would either not change or would increase under Alternative 2A as compared to deliveries under conditions in 2060 without Alternative 2A if sea level rise and climate change conditions are considered the same under both scenarios. For reasons discussed in Section 7.3.1, *Methods for Analysis*, DWR has identified effects of action alternatives under CEQA separately from the effects of increased water demands, sea level rise, and climate change, which would occur without and independent of the BDCP. Absent these factors, the impacts of Alternative 2A with respect to groundwater levels are considered to be less than significant.

The SWP deliveries to southern California areas under Alternative 2A would be greater than those under Existing Conditions, even considering the effects of increased water demands north of the Delta, sea level rise, and climate change. As a result, groundwater withdrawals would not need to be increased under Alternative 2A as compared to Existing Conditions, and the impact associated with groundwater levels and recharge in Southern California areas would be less than significant. Therefore, Alternative 2A would not in itself result in a significant impact on groundwater levels and associated well yields in the San Joaquin and Tulare Service Areas and southern California.

Impact GW-9: Degrade Groundwater Quality

NEPA Effects: As discussed under impact GW-8 above, surface water deliveries to the CVP and SWP Export Service Areas are expected to increase under this alternative as compared to the No Action Alternative, which is anticipated to result in a decrease in groundwater use. The decreased groundwater use is not anticipated to alter regional patterns of groundwater flow in the Export Service Areas. Therefore, it is not anticipated this would result in an adverse effect on groundwater quality in the Export Service Areas.

CEQA Conclusion: As discussed under impact GW-8 above, the impacts of Alternative 2A with respect to groundwater levels are considered to be less than significant. Therefore, no significant groundwater quality impacts are anticipated during the implementation of Alternative 2A because it is not anticipated to alter regional groundwater flow patterns in the Export Service Areas. Therefore, this impact is considered less than significant. No mitigation is required.

Impact GW-10: Result in Groundwater Level-Induced Land Subsidence

The potential for groundwater level–induced land subsidence under this Alternative would be similar to that under Alternatives 1A and 6A. See Impact GW-10 under Alternative 1A.

7.3.3.6 Alternative 2B—Dual Conveyance with East Alignment and Five Intakes (15,000 cfs; Operational Scenario B)

Facilities construction under Alternative 2B would be identical to those described for Alternative 1B. Alternative 2B would involve relocation of two of the intakes to a location south of the confluence of Sutter and Steamboat sloughs and the Sacramento River.

Operations of the facilities and implementation of the conservation measures under Alternative 2B would be identical to actions described under Alternative 2A.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1B; construction activities under Alternative 2B would be similar to those under Alternative 1B. The impacts on groundwater levels resulting from dewatering activities are dependent on the local hydrogeology and the depth and duration of dewatering required. Because all of the pump stations associated with the intakes are located in areas of similar geology and hydrogeology, and the dewatering configurations are identical for each of the facilities, it would be expected that the impacts of construction activities on local groundwater levels and associated well yields would be similar. The only differences would be associated with the location of the intakes. Both alternatives use intakes 1, 2, and 3. However, Alternative 2B uses intakes 6 and 7 as opposed to intakes 4 and 5 for Alternative 1B. The different intake locations would also add two different conveyance pipelines between the intakes and the canal. This intake location difference does not change the type of dewatering impact and the magnitude of the effect is expected to be similar. Therefore, the effects and mitigation measures described for Alternative 1B are valid for this alternative as well.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1B; operations activities under Alternative 2B would be similar to those under Alternative 1B.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1B; construction and operations activities under Alternative 2B would be similar to those under Alternative 1B.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1B; construction activities under Alternative 2B would be similar to those under Alternative 1B. The impacts on groundwater levels resulting from dewatering activities are dependent on the local hydrogeology and the depth and duration of dewatering required. Because all of the pump stations associated with the intakes are located in areas of similar geology and hydrogeology, and the dewatering configurations are identical for each of the facilities, it would be expected that the impacts of construction activities on local agricultural drainage would be similar. The only differences would be associated with the location of the intakes. However, Alternative 2B uses intakes 6 and 7 as opposed to intakes 4 and 5 for Alternative 1B. The different intake locations would also add two different conveyance pipelines between the intakes and the canal. This intake location difference does not change the type of dewatering impact and the magnitude of the effect is expected to be similar. Therefore, the effects described for Alternative 1B are valid for this alternative as well.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1B; operations activities under Alternative 2B would be similar to those under Alternative 1B.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1B; CM2–CM22 under Alternative 2B would result in effects similar to those under Alternative 1B.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1B; CM2–CM22 under Alternative 2B would result in effects similar to those under Alternative 1B.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-8 under Alternative 2A; project operations under Alternative 2B would be identical to those under Alternative 2A.

Impact GW-9: Degrade Groundwater Quality

See Impact GW-9 under Alternative 2A; project operations under Alternative 2B would be identical to those under Alternative 2A.

Impact GW-10: Result in Groundwater Level-Induced Land Subsidence

See Impact GW-10 under Alternative 2A; project operations under Alternative 2B would be identical to those under Alternative 2A.

7.3.3.7 Alternative 2C—Dual Conveyance with West Alignment and Intakes W1–W5 (15,000 cfs; Operational Scenario B)

Facilities construction under Alternative 2C would be identical to those described for Alternative 1C.

Operations of the facilities and implementation of the conservation measures under Alternative 2C would be identical to actions described under Alternative 2A.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1C; construction activities under Alternative 2C would be the same as those under Alternative 1C. Both alternatives use the same intakes and conveyance footprint.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1C; operations activities under Alternative 2C would be the same as those under Alternative 1C.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1C; construction and operations activities under Alternative 2C would the same as those under Alternative 1C.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1C; construction activities under Alternative 2C would be the same as those under Alternative 1C. Both alternatives use the same intakes and conveyance footprint.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1C; operations activities under Alternative 2C would be the same as under Alternative 1C.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1C; CM2–CM22 under Alternative 2C would result in effects similar to those under Alternative 1C.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1C; CM2–CM22 under Alternative 2C would result in effects similar to those under Alternative 1C.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-8 under Alternative 2A; project operations under Alternative 2C would be identical to those under Alternative 2A.

Impact GW-9: Degrade Groundwater Quality

See Impact GW-9 under Alternative 2A; project operations under Alternative 2C would be identical to those under Alternative 2A.

Impact GW-10: Result in Groundwater Level–Induced Land Subsidence

See Impact GW-10 under Alternative 2A; project operations under Alternative 2C would be identical to those under Alternative 2A.

7.3.3.8 Alternative 3—Dual Conveyance with Pipeline/Tunnel and Intakes 1 and 2 (6,000 cfs; Operational Scenario A)

Facilities construction under Alternative 3 would be similar to those described for Alternative 1A, but with only two intakes.

Operations under Alternative 3 would be identical as under Alternative 1A except that there would be more reliance on the south Delta intakes due to less capacity provided by the north Delta intakes. Under Alternative 1A, the total north Delta intake capacity would be 15,000 cfs as compared with 6,000 cfs under Alternative 3.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1A; construction activities under Alternative 3 would be similar to those under Alternative 1A. The impacts on groundwater levels resulting from dewatering activities are dependent on the local hydrogeology and the depth and duration of dewatering required. Because all of the pump stations associated with the intakes are located in areas of similar geology and hydrogeology, and the dewatering configurations are identical for each of the facilities, it would be expected that the impacts of construction activities on local groundwater levels and associated well yields would be similar. The only difference would be associated with the number of intakes used. This alternative would use two intakes instead of the five intakes used in Alternative 1. This would result in decreased dewatering impacts and fewer wells being affected.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1A; operations activities under Alternative 3 would be the same as those under Alternative 1A. Both alternatives use the same forebay locations, which, in the absence of design features intended to minimize seepage, would be the main locations of potential impacts to groundwater levels.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1A; construction and operations activities under Alternative 3 would be similar to those under Alternative 1A, but to a lesser magnitude, because only two intakes would be constructed.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1A; construction activities under Alternative 3 would be similar to those under Alternative 1A, but to a lesser magnitude, because only two intakes would be constructed.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1A; operations activities under Alternative 3 would be similar to those under Alternative 1A.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 3 would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 3 would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: Total long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 3 would be higher than under the No Action Alternative, as described in Chapter 5, *Water Supply*, and Table 7-7. Alternative 3 operations and deliveries would be very similar to the ones described for Alternative 1A.

Increases in surface water deliveries attributable to project operations from the implementation of Alternative 3 are anticipated to result in a corresponding decrease in groundwater use in the Export Service Areas, as discussed in Section 7.3.3.2.

CVHM modeling results show that groundwater levels would rise beneath the Corcoran Clay by up to 10 feet in most areas in the western portions of the San Joaquin and Tulare Basins, but could rise up to 250 feet under WBS 14 (i.e., Westside and Northern Pleasant Valley basins) as compared with the No Action Alternative. The forecasted maximum groundwater level changes occur in August because agricultural groundwater pumping is typically highest during this month.

The forecasted groundwater level rises across the Export Service Areas during a typical peak groundwater level change condition in August as compared to the No Action Alternative, are shown in Figure 7-25. These forecasted changes in groundwater levels result from decreased agricultural pumping during the irrigation season due to an increase in surface water deliveries from the Delta under Alternative 3 in the western portion of the San Joaquin and Tulare Lake basins.

Effects on groundwater levels due to the implementation of Alternative 3 are similar to the ones described for Alternative 1A. However, the geographical extent of the impacts under Alternative 3 is slightly different.

Overall, the CVP and SWP deliveries to agricultural areas in the San Joaquin and Tulare Service Areas under this alternative would be greater than for the No Action Alternative. This would result in an overall decrease in groundwater pumping and a corresponding increase in groundwater levels.

The SWP deliveries to Southern California areas under Alternative 3 would be greater than those under the No Action Alternative. Implementation of Alternative 3 would result in an overall decrease in groundwater pumping and a corresponding increase in groundwater levels.

CEQA Conclusion: Total long-term average annual surface water deliveries to the CVP and SWP Service Areas under Alternative 3 would be greater than those under Existing Conditions in the San Joaquin and Tulare export service areas, which would cause a decrease in groundwater pumping and a resulting increase in groundwater levels in some areas.

CVHM modeling results show that groundwater levels would rise beneath the Corcoran Clay by up to 100 feet under WBS 14 (i.e., Westside and Northern Pleasant Valley basins) as compared with Existing Conditions (Figure 7-26). The forecasted maximum groundwater level changes occur in August because agricultural groundwater pumping is typically highest during this month. On the eastern side of the San Joaquin and Tulare Lake basins, climate change impacts on stream flows could result in a decline in groundwater levels of up to 25 feet. In addition, if reduced stream flows are not adequate to meet the surface water diversion requirements, groundwater pumping could increase, resulting in a further decline in groundwater levels.

For reasons discussed in Section 7.3.1, *Methods for Analysis*, DWR has identified effects of action alternatives under CEQA separately from the effects of increased water demands, sea level rise, and climate change, which would occur without and independent of the BDCP. Absent these factors, the impacts of Alternative 3 with respect to groundwater levels are considered to be less than significant.

The SWP deliveries to areas outside of the Central Valley under Alternative 3 would be greater than those under Existing Conditions. The impact associated with groundwater levels and recharge in those areas would be less than significant. Therefore, Alternative 3 would not result in a significant impact on groundwater levels and associated well yields in the San Joaquin and Tulare Service Areas and southern California.

Impact GW-9: Degrade Groundwater Quality

NEPA Effects: The decrease in groundwater pumping that would occur in the Export Service Areas (as described in Impact GW-8) in response to greater CVP and SWP water supply availability would not alter regional patterns of groundwater flow and therefore would not degrade groundwater quality in the area. No adverse effect to groundwater quality is anticipated as a result of implementing Alternative 3.

CEQA Conclusion: Implementation of Alternative 3 is not anticipated to degrade groundwater quality in the Export Service Areas. This impact is considered less than significant. No mitigation is required.

Impact GW-10: Result in Groundwater Level–Induced Land Subsidence

The potential for groundwater level–induced land subsidence under Alternative 3 would be similar to that under Alternatives 1A and 6A. See Impact GW-10 under Alternative 1A.

7.3.3.9 Alternative 4—Dual Conveyance with Modified Pipeline/Tunnel and Intakes 2, 3, and 5 (9,000 cfs; Operational Scenario H)

Facilities construction under Alternative 4 would be similar to those described for Alternative 1A with only three intakes. In addition, the Intermediate Forebay for Alternative 4 differs significantly from the one that would be constructed under Alternative 1A. The Alternative 4 Intermediate Forebay is reduced in size (from 720 acres to 40 acres in water surface area) and is located further away from the Sacramento River and further south from the intakes as compared to the Alternative 1A. This smaller forebay footprint would result in reduced effects on groundwater resources as compared to Alternative 1A. Alternative 4 will result in the modification and expansion of Clifton Court Forebay to include the Byron Tract area, while for Alternative 1A, Clifton Court Forebay would remain the same and the new Byron Tract Forebay would be constructed adjacent. The overall footprint of the forebay (or forebays) would be similar for both alternatives, resulting in similar effects on groundwater in the vicinity of Clifton Court Forebay.

Operations under Alternative 4 would be identical to those under Alternative 2A except that there would be more reliance on the south Delta intakes due to less capacity provided by the north Delta intakes. Alternative 4 was simulated in CALSIM II with Scenario H, which included a decision tree analysis, as described in Chapter 3. Alternative 4 includes the following four sub-scenarios.

- Alternative 4 Scenario H1: low Delta outflow
- Alternative 4 Scenario H2: includes enhanced Spring Delta outflow, excludes Fall X2
- Alternative 4 Scenario H3: excludes enhanced Spring Delta outflow; includes Fall X2
- Alternative 4 Scenario H4: high Delta outflow

The discussion below presents a combination of simulated quantitative results and a qualitative approach, since the only scenario that was simulated with CVHM and CVHM-D is Scenario H3 due to the fact that it falls within the range of delivery resulting from the other scenarios and provides a realistic average.

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Construction and operation of Alternative 4 facilities would be similar under each of the operational scenarios for the purposes of this analysis, since the footprint is the same. Therefore, the description of impacts that were simulated with CVHM-D for Scenario H3 below is applicable to each Alternative 4 scenario.

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1A; construction activities under Alternative 4 would generally be similar to those under Alternative 1A. The impacts on groundwater levels resulting from dewatering activities are dependent on the local hydrogeology and the depth and duration of dewatering required. Because all of the pump stations associated with the intakes are located in areas of similar geology and hydrogeology, and the dewatering configurations are identical for each of the facilities, it would be expected that the impacts of construction activities on local groundwater levels and associated well yields would be similar with respect to intake and intake pumping plant construction. The only difference would be associated with the number of intakes used. This alternative uses three intakes instead of five used in Alternative 1A. This would result in decreased dewatering effects and fewer wells being affected.

NEPA Effects: Dewatering would temporarily lower groundwater levels in the vicinity of the dewatering sites. Two areas could be subject to substantial lowering of groundwater levels: (1) In the vicinity of intake pump stations 2, 3, and 5; and (2) in the vicinity of the expanded Clifton Court Forebay portion that includes the Byron Tract area. Groundwater-level lowering from construction dewatering activities is forecasted to be less than 10 feet in the vicinity of the intakes and less than 20 feet in the vicinity of the forebay. The horizontal distance from the boundary of the excavation to locations where forecasted groundwater levels are 5 feet below the static groundwater level is defined as the “radius of influence” herein. The radius of influence is forecasted to extend approximately 2,600 feet from the Byron Tract Forebay excavation and from the intake 2, 3, and 5 excavations (Figure 7-27). Groundwater would return to pre-pumping levels over the course of several months. Simulation results suggest that two months after pumping ceases, water levels would be within 5 feet of pre-pumping water levels. The sustainable yield of some wells might temporarily be affected by the lower water levels such that they are not able to support existing land uses. The construction of conveyance features would result in effects on groundwater levels and associated well yields that would be temporary. It should be noted that the forecasted impacts described above reflect a worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis.

CEQA Conclusion: Construction activities associated with conveyance facilities under CM1 for Alternative 4 including temporary dewatering and associated reduced groundwater levels have the potential to temporarily affect the productivity of existing nearby water supply wells. Groundwater levels within 2,600 feet of the areas to be dewatered are anticipated to experience groundwater level reductions of less than 20 feet for the duration of the dewatering activities and up to 2 months after dewatering is completed. Nearby wells could experience significant reductions in well yield, if they are shallow wells and may not be able to support existing land uses. The temporary impact on groundwater levels and associated well yields is considered significant because construction-related dewatering might affect the amount of water supplied by shallow wells located near the CM1 construction sites. Mitigation Measure GW-1 identifies a monitoring procedure and options for maintaining an adequate water supply for land owners that experience a reduction in groundwater production from wells within 2,600 feet of construction-related dewatering activities. It should be noted that the forecasted impacts described above reflect a worst-case scenario as the option of installing seepage cutoff walls during dewatering was not considered in the analysis. Implementing Mitigation Measure GW-1 would help address these effects; however, the impact may remain significant because replacement water supplies may not meet the preexisting demands or planned land use demands of the affected party. In some cases this impact might temporarily be significant and unavoidable until groundwater elevations recover to pre-construction conditions which could require several months after dewatering operations cease.

Mitigation Measure GW-1: Maintain Water Supplies in Areas Affected by Construction Dewatering

See Mitigation Measure GW-1 under Impact GW-1 in the discussion of Alternative 1A.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: The new Intermediate Forebay and the expanded Clifton Court Forebay would be constructed to comply with the requirements of the DSD which include design features intended to minimize seepage under the embankments. In addition, the forebays will include a seepage cutoff wall installed to the impervious layer and a toe drain around the forebay embankment, to capture water and pump it back into the forebay. Any potential vertical seepage under the smaller Intermediate Forebay would also be captured by the toe drain. However, operation of Alternative 4 would result in groundwater level increases in the vicinity of the expanded Clifton Court Forebay portion at Byron Tract due to groundwater recharge, similar to Alternative 1A.

Operation of the tunnel would have no impact on existing wells or yields given the facilities would be located more than 100 feet underground and would not substantially alter groundwater levels in the vicinity.

CEQA Conclusion: The new Intermediate Forebay and the expanded Clifton Court Forebay will include design features intended to minimize seepage under the embankments and a toe drain around the forebay embankment, to capture water and pump it back into the forebay. Any potential vertical seepage under the smaller Intermediate Forebay would also be captured by the toe drain. However, operation of Alternative 4 would result in groundwater level increases in the vicinity of the expanded Clifton Court Forebay portion at Byron Tract due to groundwater recharge, similar to Alternative 1A, which would not reduce the yields of nearby wells.

Operation of the tunnel would have no impact on existing wells or yields given these facilities would be located over 100 feet underground and would not substantially alter groundwater levels in the vicinity.

Groundwater levels in the Suisun Marsh area under Alternative 4 are forecasted to rise by 1 to 5 feet compared with Existing Conditions, as described for Alternative 1A. This groundwater level rise is primarily attributable to sea level rise and climate change conditions in the Alternative 1A CVHM-D simulation. However, the anticipated effects of climate change and sea level rise are provided for information purposes only and do not lead to mitigation measures.

Therefore, this impact would be less than significant. No mitigation is required.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1A; construction and operations activities under Alternative 4 would be similar to those under Alternative 1A, but to a lesser magnitude, because only three intakes would be constructed.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1A; construction activities under Alternative 4 would be similar to those under Alternative 1A, but to a lesser magnitude, because only three intakes would be constructed.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: As described in Chapter 3 *Description of Alternatives*, under Alternative 4, the Intermediate Forebay and the expanded Clifton Court Forebay will include a seepage cutoff wall to the impervious layer and a toe drain around the forebay embankment, to capture water and pump it back into the forebay. These design measures will greatly reduce any potential for seepage onto adjacent lands and avoid interference with agricultural drainage in the vicinity of the Intermediate Forebay. Once constructed, the operation of the forebay would be monitored to ensure seepage does not exceed performance requirements.

However, operation of Alternative 4 would result in local changes in shallow groundwater flow patterns adjacent to the expanded Clifton Court Forebay portion at Byron Tract, where groundwater recharge from surface water would result in groundwater level increases, similar to Alternative 1A. If existing agricultural drainage systems adjacent to the forebay are not adequate to accommodate the additional drainage requirements, operation of the forebay could interfere with agricultural drainage in the Delta.

CEQA Conclusion: As described in Chapter 3 *Description of Alternatives*, under Alternative 4, the Intermediate Forebay and the expanded Clifton Court Forebay will include a seepage cutoff wall to the impervious layer and a toe drain around the forebay embankment, to capture water and pump it back into the forebay. These design measures will greatly reduce any potential for seepage onto adjacent lands and avoid interference with agricultural drainage in the vicinity of the Intermediate Forebay. Once constructed, the operation of the forebay would be monitored to ensure seepage does not exceed performance requirements.

However, operation of Alternative 4 would result in local changes in shallow groundwater flow patterns adjacent to the expanded Clifton Court Forebay portion at Byron Tract, caused by groundwater recharge from surface water, and could cause significant impacts to agricultural drainage where existing systems are not adequate to accommodate the additional drainage requirements, similar to Alternative 1A. Implementation of Mitigation Measure GW-5 is anticipated to reduce this impact to a less-than-significant level in most instances, though in some instances mitigation may be infeasible due to factors such as costs that would be imprudent to bear in light of the fair market value of the affected land. The impact is therefore significant and unavoidable as applied to such latter properties.

In addition, as described for Impact GW-2, groundwater levels are projected to increase in Suisun Marsh under Alternative 1A compared to Existing Conditions, primarily due to sea level rise and climate change conditions as simulated with the Alternative 1A CVHM-D run. These increases in groundwater levels could affect agricultural drainage in the Suisun Marsh area, but do not in and of themselves require mitigation.

Mitigation Measure GW-5: Agricultural Lands Seepage Minimization

Please see Mitigation Measure GW-5 under Impact GW-5 in the discussion of Alternative 1A.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 4 would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 4 would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: Total long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 4 vary for each of the scenarios, compared to the No Action Alternative.

The four operational scenarios represent a range of surface water exports to the CVP and SWP Service Areas. In general, Scenario H1 includes the highest total long-term average annual water deliveries to the CVP and SWP Service Areas, while Scenario H4 includes the lowest total long-term average annual water deliveries to the CVP and SWP Service Areas. These two scenarios reflect the range of effects that would result from the four potential outcomes under Alternative 4, the effects associated with H2 and H3 fall within this range.

For the San Joaquin and Tulare export areas, each of the four potential outcomes provides higher surface water deliveries under Alternative 4, compared to the No Action Alternative. Alternative 4 Scenario H3 was simulated with CVHM, and was used to provide an example impacts analysis for an outcome that is between the highest and the lowest deliveries. The discussion below provides an impact discussion based on CVHM simulation results for Alternative 4 Scenario H3. The impacts of Scenarios H1, H2, and H4 will be similar to those under Scenario H3, but with the magnitude of the impacts proportional to the change in the quantity of CVP/SWP surface water supplies delivered to the SWP/CVP Export Service Areas under each scenario.

Total long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 4 Scenario H3 would be higher than under the No Action Alternative, as described in Chapter 5, *Water Supply*, and Table 7-7. Increases in surface water deliveries attributable to project operations from the implementation of Alternative 4 are anticipated to result in a corresponding decrease in groundwater use in the Export Service Areas, as compared with the No Action Alternative, as discussed in Section 7.3.3.2.

CVHM modeling results for groundwater under the Corcoran Clay layer show that levels would rise up to 10 feet in most areas in the western and southern portions of the Valley, but could increase by up to 250 feet under WBS 14 (i.e., Westside and Northern Pleasant Valley basins) as compared with the No Action Alternative. The forecasted maximum groundwater level changes occur in August because agricultural groundwater pumping is typically highest during this month.

The forecasted groundwater level rises across the Export Service Areas during a typical peak groundwater level change condition in August, as compared to the No Action Alternative are shown in Figure 7-28. These forecasted changes in groundwater levels result from decreased agricultural pumping during the irrigation season due to an increase in surface water deliveries from the Delta under Alternative 4 Scenario H3 in the western portion of the San Joaquin and Tulare Lake basins. Indirect effects of increased groundwater levels include a reduction in pumping costs due to reduced lift requirements, a reduced potential for the inducement of inelastic subsidence, and an increase in the available yields from pumping wells within the affected area.

The SWP deliveries to Southern California areas under Alternative 4 Scenarios H1, H2, and H3 would be greater than those under the No Action Alternative. Implementation of Alternative 4 with these scenarios would result in an overall decrease in groundwater pumping and a corresponding increase in groundwater levels.

The SWP deliveries to Southern California areas under Alternative 4 Scenario H4 would be less than those under the No Action Alternative. Implementation of Alternative 4 Scenario H4 may result in additional groundwater pumping and a potential corresponding decrease in groundwater levels. This could result in adverse effects associated with groundwater levels and recharge in Southern California areas. However, opportunities for additional pumping might be limited by basin adjudications and other groundwater management programs. Additionally, as discussed in Appendix 5B, *Responses to Reduced South of Delta Water Supplies*, adverse effects might be avoided due to the existence of various other water management options that could be undertaken in response to reduced exports from the Delta. These options include wastewater recycling and reuse, increased water conservation, water transfers, construction of new local reservoirs that could retain Southern California rainfall during wet years, and desalination.

Even if the effect is adverse, feasible mitigation would not be available to diminish this effect due to a number of factors. First, State Water Contractors currently and traditionally have received variable water supplies under their contracts with DWR due to variations in hydrology and regulatory constraints and are accustomed to responding accordingly. Any reductions associated with this impact would be subject to these contractual limitations. Under standard state water contracts, the risk of shortfalls in exports is borne by the contractors rather than DWR. As a result of this variability, many Southern California water districts have complex water management strategies that include numerous options, as described above, to supplement SWP surface water supplies. These water districts are in the best position to determine the appropriate response to reduced imports from the Delta. Second, as noted above, it may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights. Finally, in many groundwater basins, additional groundwater pumping might exacerbate existing overdraft and subsidence conditions, even if such pumping is legally permissible because the affected basin has not been adjudicated or no other groundwater management program is in place.

CEQA Conclusion: For the San Joaquin and Tulare export areas, each of the four potential outcomes provides lower surface water deliveries under Alternative 4, compared to Existing Conditions, largely because of effects due to climate change, sea level rise, and increased water demand north of the Delta. Alternative 4 Scenario H3 was simulated with CVHM, and was used to provide an example impacts analysis for an outcome that is between the highest and the lowest deliveries. Modeling predicts that groundwater pumping under Alternative 4 Scenario H3 would be greater than under Existing Conditions, and that groundwater levels in some areas would be lower than under Existing Conditions.

CVHM modeling results of groundwater under the Corcoran Clay layer show that levels would decrease by up to 250 feet under WBS14 (i.e., Westside and Northern Pleasant Valley basins) as compared with Existing Conditions. The forecasted groundwater level changes across the Export Service Areas during a typical peak groundwater level change condition in August as compared to Existing Conditions are shown in Figure 7-29. These forecasted changes in groundwater levels under Alternative 4 result from increased agricultural pumping during the irrigation season due to a decrease in surface water deliveries from the Delta to the western portion of the San Joaquin and Tulare Lake basins. On the eastern side of the San Joaquin and Tulare Lake basins, climate change impacts on stream flows could result in a decline in groundwater levels of up to 50 feet. In addition, if reduced stream flows are not adequate to meet the surface water diversion requirements, groundwater pumping could increase, resulting in a further decline in groundwater levels.

As shown above in the NEPA analysis, SWP and CVP deliveries would either not change or would increase under Alternative 4 for all scenarios as compared to deliveries under conditions in 2060 without Alternative 4 if sea level rise and climate change conditions are considered the same under both scenarios. For reasons discussed in Section 7.3.1, *Methods for Analysis*, DWR has identified effects of action alternatives under CEQA separately from the effects of increased water demands, sea level rise, and climate change, which would occur without and independent of the BDCP. Absent these factors, the impacts of Alternative 4 for each of the four scenarios with respect to groundwater levels are considered to be less than significant.

Unlike the NEPA analysis where scenarios H1 and H4 bounded the range of anticipated impacts, the impacts relative to the Existing Conditions baseline are more variable. The SWP deliveries to Southern California areas under Alternative 4 Scenarios H1 and H3 would be greater than those under Existing Conditions. This would result in beneficial impacts associated with groundwater levels and recharge in Southern California areas. However, the SWP deliveries to Southern California areas under Alternative 4 Scenarios H2 and H4 would be less than those under Existing Conditions. For Scenario H2, the reduced surface water deliveries would be largely due to the effects of climate change, sea level rise, and increased water demand north of the Delta, and, as described above for the Tulare and San Joaquin areas, absent these factors, the impacts of Scenario H2 on groundwater levels would be less than significant. For Scenario H4, reduced surface water deliveries could result in significant impacts associated with groundwater levels and recharge in Southern California areas.

As discussed above in the NEPA conclusion, Southern California water districts may be able to avoid this impact due to various water management options. For reasons also discussed above, no feasible mitigation would be available to mitigate this impact if it is significant. Due to these uncertainties, the overall impact for Alternative 4 (Scenarios H1–H4) is considered significant and unavoidable.

Impact GW-9: Degrade Groundwater Quality

NEPA Effects: As discussed under Impact GW-8, surface water deliveries to the CVP and SWP Export Service Areas in the San Joaquin Valley and Tulare Basin under all Alternative 4 scenarios (H1–H4) outcomes are expected to increase as compared to the No Action Alternative. Increased surface water deliveries could result in a decrease in groundwater use. The decreased groundwater use is not anticipated to alter regional patterns of groundwater flow in these service areas. Therefore, it is not anticipated this would result in an adverse effect on groundwater quality in these areas.

In contrast, under Scenario H4 there would be reduced SWP supplies in Southern California. It is unclear, however, whether such reductions would lead to increased groundwater pumping for reasons discussed in connection to Impact GW-8. If groundwater pumping is increased, there could be resulting changes in regional patterns of groundwater flow and a change in groundwater quality. Due to the uncertainty associated with these effects, this effect is considered adverse. For the same reasons discussed earlier in connection with the possibility of increased groundwater pumping in Southern California, there is no feasible mitigation available to mitigate any changes in regional groundwater quality.

CEQA Conclusion: As discussed under Impact GW-8 above, the impacts of Alternative 4 under all scenarios with respect to groundwater levels are considered to be less than significant in the CVP and SWP Export Service Areas in the San Joaquin Valley and Tulare Basin. Therefore, no significant groundwater quality impacts are anticipated in these areas during the implementation of Alternative 4 because it is not anticipated to alter regional groundwater flow patterns. Therefore, this impact is considered less than significant with respect to these areas. The same is true for Scenarios H1-H3 for the Southern California SWP Export Service Areas.

However, implementation of Alternative 4 Scenarios H4 could degrade groundwater quality in portions of the Southern California SWP Export Service Areas; this impact is considered significant due to the possibility of increased groundwater pumping and the resulting effects on regional groundwater flow patterns. As discussed above, there is no feasible mitigation available to address this significant impact. The impact would be considered significant and unavoidable in these areas.

Due to the uncertainties identified in connection with the potential response to Impact GW-8 under Scenario H4 in Southern California, the overall impact for Impact GW-9 Alternative 4 (Scenarios H1–H4) is considered significant and unavoidable.

Impact GW-10: Result in Groundwater Level–Induced Land Subsidence

The potential for groundwater level–induced land subsidence under Alternative 4 would be similar to that under Alternative 1A. See Impact GW-10 under Alternative 1A.

7.3.3.10 Alternative 5—Dual Conveyance with Pipeline/Tunnel and Intake 1 (3,000 cfs; Operational Scenario C)

Facilities construction under Alternative 5 would be similar to those described for Alternative 1A with only one intake.

Operations under Alternative 5 would be similar to those under Alternative 1A except for a few actions, as described in Chapter 6, *Surface Water*.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1A; construction activities under Alternative 5 would be similar to those under Alternative 1A. The impacts on groundwater levels resulting from dewatering activities are dependent on the local hydrogeology and the depth and duration of dewatering required. Because all of the pump stations associated with the intakes are located in areas of similar geology and hydrogeology, and the dewatering configurations are identical for each of the facilities, it would be expected that the impacts of construction activities on local groundwater levels and associated well yields would be similar. The only difference would be associated with the number of intakes used. This alternative uses one intake instead of five used in Alternative 1A. This would result in decreased dewatering effects and fewer wells being affected.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1A; operations activities under Alternative 5 would be similar to those under Alternative 1A. Both alternatives use the same forebay locations, which, in the absence of design features intended to minimize seepage, would be the main locations of potential impacts on groundwater levels.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1A; construction and operations activities under Alternative 5 would be similar to those under Alternative 1A, but to a lesser magnitude, because only one intake would be constructed.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1A; construction activities under Alternative 5 would be similar to those under Alternative 1A, but to a lesser magnitude, because only one intake would be constructed.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1A; operations activities under Alternative 5 would be similar to those under Alternative 1A.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 5 would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 5 would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: Total long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 5 would be higher than under the No Action Alternative, as described in Chapter 5, *Water Supply*, and Table 7-7. Increases in surface water deliveries attributable to project operations from the implementation of Alternative 5 are anticipated to result in a corresponding decrease in groundwater use in the Export Service Areas, as compared with the No Action Alternative as discussed in Section 7.3.3.2.

CVHM modeling results show that groundwater levels would rise beneath the Corcoran Clay of up to 10 feet in most areas in the western and southern portions of the valley, but could increase by up to 250 feet under WBS 14 (i.e., Westside and Northern Pleasant Valley basins of the western Tulare Basin).

The forecasted maximum groundwater level declines across the Export Service Areas during a typical peak groundwater level change condition in August, as compared with the No Action Alternative, are shown in Figure 7-30.

The SWP deliveries to Southern California areas under Alternative 5 would be higher than those under the No Action Alternative. Therefore, implementation of Alternative 5 would result in an overall decrease in groundwater pumping and a corresponding increase in groundwater levels. Therefore, adverse effects on groundwater levels are not expected to occur due to the implementation of Alternative 5 in these areas.

CEQA Conclusion: Total long-term average annual surface water deliveries to the CVP and SWP Service Areas under Alternative 5 would be less than under Existing Conditions in the San Joaquin and Tulare export service areas, largely because of effects due to climate change, sea level rise, and increased water demand north of the Delta. As a result, modeling predicts that groundwater pumping under Alternative 5 would be greater than under Existing Conditions, and that groundwater levels in some areas would be lower than under Existing Conditions.

CVHM modeling results show that groundwater levels would decrease by up to 250 feet beneath the Corcoran Clay under WBS14 (i.e., Westside and Northern Pleasant Valley basins) as compared with Existing Conditions. The forecasted groundwater level changes across the Export Service Areas during a typical peak groundwater level change condition in August as compared to Existing Conditions are shown in Figure 7-31. These forecasted changes in groundwater levels result from increased agricultural pumping during the irrigation season due to a decrease in surface water deliveries from the Delta under Alternative 5 in the western portion of the San Joaquin and Tulare Lake basins. On the eastern side of the San Joaquin and Tulare Lake basins, climate change impacts on stream flows could result in a decline in groundwater levels of up to 50 feet. In addition, if reduced stream flows are not adequate to meet the surface water diversion requirements, groundwater pumping could increase, resulting in a further decline in groundwater levels.

The SWP deliveries to Southern California areas under Alternative 5 would be less than those under Existing Conditions, which could result in additional groundwater pumping and a corresponding decrease in groundwater levels in some areas.

As shown above in the NEPA analysis, SWP and CVP deliveries would either not change or would increase under Alternative 5 as compared to deliveries under conditions in 2060 without Alternative 5 if sea level rise and climate change conditions are considered the same for both scenarios. For reasons discussed in Section 7.3.1, *Methods for Analysis*, DWR has identified effects of action alternatives under CEQA separately from the effects of increased water demands, sea level rise, and climate change, which would occur without and independent of the BDCP. Absent these factors, the impacts of Alternative 5 with respect to groundwater levels are considered to be less than significant.

Impact GW-9: Degrade Groundwater Quality

NEPA Effects: As discussed under impact GW-8 above, surface water deliveries to the CVP and SWP Export Service Areas are expected to increase under this alternative as compared to the No Action Alternative, which is anticipated to result in a decrease in groundwater use. The decreased groundwater use is not anticipated to alter regional patterns of groundwater flow or groundwater quality in the Export Service Areas. Therefore, it is not anticipated this would result in an adverse effect on groundwater quality in the Export Service Areas.

CEQA Conclusion: As discussed under impact GW-8 above, the impacts of Alternative 5 with respect to groundwater levels are considered to be less than significant. Therefore, no significant groundwater quality impacts are anticipated during the implementation of Alternative 5 because it is not anticipated to alter regional patterns of groundwater flow in the Export Service Areas. Therefore, this impact is considered less than significant. No mitigation is required.

Impact GW-10: Result in Groundwater Level–Induced Land Subsidence

The potential for groundwater level-induced land subsidence under Alternative 5 would be similar to that under Alternatives 1A and 6A. See Impact GW-10 under Alternative 1A.

7.3.3.11 Alternative 6A—Isolated Conveyance with Pipeline/Tunnel and Intakes 1–5 (15,000 cfs; Operational Scenario D)

Facilities construction under Alternative 6A would be similar to those described for Alternative 1A. The different operational scenario under Alternative 6A would be reflected in changes in groundwater conditions in the Export Service Areas.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1A; construction activities under Alternative 6A would be identical to those under Alternative 1A.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1A; construction activities under Alternative 6A would be identical to those under Alternative 1A.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1A; the construction activities would be identical to those under Alternative 1A.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1A; construction activities under Alternative 6A would be identical to those under Alternative 1A.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1A; construction activities under Alternative 6A would be identical to those under Alternative 1A.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 6A would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 6A would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: Total long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 6A would be less than under the No Action Alternative, as described in Chapter 5, *Water Supply*, and Table 7-7.

Decreases in surface water deliveries attributable to project operations from the implementation of Alternative 6A are anticipated to result in a corresponding increase in groundwater use in the Export Service Areas, as compared with the No Action Alternative as discussed in Section 7.3.3.2.

CVHM modeling results show that Alternative 6A is forecasted to result in groundwater level declines beneath the Corcoran Clay of up to 25 feet in most areas but could exceed 200 feet under WBS 14 (i.e., Westside and Northern Pleasant Valley basins of the western Tulare Basin). The maximum groundwater level changes are forecasted to typically occur in August because agricultural groundwater pumping is typically highest in this month.

The forecasted groundwater level decreases across the San Joaquin Valley and Tulare Basins during a typical peak groundwater level change condition in August, as compared with the No Action Alternative, are shown in Figure 7-32. These forecasted changes in groundwater levels result from increased agricultural pumping during the irrigation season because of a decrease in surface water deliveries from the Delta under Alternative 6A.

Overall, the CVP and SWP deliveries to agricultural areas in the San Joaquin Valley and Tulare Service Areas under this alternative would be less than for the No Action Alternative. The sustainable yield of some wells might be affected by the lower water levels such that they are not able to support the existing or planned land uses for which permits have been granted. The increase in groundwater pumping would cause an adverse effect on groundwater levels and associated well yields.

Alternative 6A is also forecasted to decrease the surface water supplies from the Delta to Export Service Areas outside of the Central Valley. If less surface water is available for municipal, industrial, and agricultural users, utilization of groundwater resources could be increased (see Chapter 5, *Water Supply*). However, in the Central Coast and Southern California, overdrafted basins have, for the most part, been adjudicated to control the amount of pumping, thus reducing the amount of groundwater resource availability.

Many groundwater basins in the San Francisco Bay Area, Central Coast, and Southern California rely on SWP/CVP surface water to recharge groundwater basins (as described in Section 7.1.1.4). Therefore, adverse effects on groundwater supplies, groundwater recharge, and local groundwater table levels are expected to result from the implementation of Alternative 6A in these Export Service Areas.

Feasible mitigation would not be available to diminish this effect due to a number of factors. First, State and federal Water Contractors currently and traditionally have received variable water supplies under their contracts with DWR and Reclamation due to variations in hydrology and regulatory constraints and are accustomed to responding accordingly. Any reductions associated with this impact would be subject to these contractual limitations. Under standard state and federal water contracts, the risk of shortfalls in exports is borne by the contractors rather than DWR or Reclamation. As a result of this variability, many of the water contractors in water districts have complex water management strategies that include numerous options to supplement CVP and SWP surface water supplies. As discussed in Appendix 5B, *Responses to Reduced South of Delta Water Supplies*, adverse effects might be avoided due to the existence of various other water management options that could be undertaken in response to reduced exports from the Delta. In urban areas, these options include wastewater recycling and reuse, increased water conservation, water transfers, construction of new local reservoirs that could retain rainfall during wet years, and desalination in coastal areas. In agricultural areas, options for responding to reduced exports include changes in cropping patterns, improvements in irrigation efficiency, water transfers, and development of new local supplies. In both rural and urban areas, the affected water districts or individual water users are in the best position to determine the appropriate response to reduced deliveries from the Delta. Second, in adjudicated groundwater basins, it may be legally impossible to extract additional groundwater without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights. Finally, in many groundwater basins in the Central Coast and Central Valley, additional groundwater pumping might exacerbate existing overdraft and subsidence conditions, even if such pumping is legally permissible because the affected basin has not been adjudicated or no other groundwater management program is in place.

CEQA Conclusion: Total long-term average annual surface water deliveries to the CVP and SWP Service Areas under Alternative 6A would be less than under Existing Conditions in the San Joaquin and Tulare export service areas. As a result, modeling predicts that groundwater pumping under Alternative 5 would be greater than under Existing Conditions, and that groundwater levels in some areas would be lower than under Existing Conditions.

CVHM modeling results show that Alternative 6A would result in groundwater level declines beneath the Corcoran Clay (Central Valley) of up to 25 feet in most areas; declines could exceed 200 feet in the Westside and Northern Pleasant Valley basins of the western Tulare Lake Basin (Figure 7-33). On the eastern side of the San Joaquin and Tulare Lake basins, climate change effects on stream flows could result in a decline in groundwater levels by as much as 25 feet. In addition, if reduced stream flows are not adequate to meet the surface water diversion requirements, groundwater pumping might increase, resulting in a further decline in groundwater level. However, effects due to climate change would occur independently of the BDCP. The anticipated effects of climate change are provided for informational purposes only, but do not lead to mitigation measures.

Decreased groundwater levels associated with increased overall groundwater use for Alternative 6A could result in significant impacts in most of the Export Service Areas and significantly impact the yield of domestic and municipal wells, such that they are not able to support the existing or planned land uses for which permits have been granted. As discussed above in the NEPA conclusion there is no feasible mitigation available to address this impact. Therefore, the impact would be considered significant and unavoidable.

Impact GW-9: Degrade Groundwater Quality

NEPA Effects: As discussed under Impact GW-8, the increase in groundwater pumping that could occur in portions of the Export Service Areas in response to reduced SWP/CVP water supply availability could alter regional patterns of groundwater flow and induce the migration of poor-quality groundwater into areas of good-quality groundwater, especially in the coastal areas of central Coast and southern California, where seawater intrusion has occurred in the past. For the same reasons discussed earlier, there is no feasible mitigation available to mitigate any changes in regional groundwater quality. This effect is considered adverse.

CEQA Conclusion: Alternative 6A could induce the degradation of groundwater quality in some areas due to the possibility of increased groundwater pumping and the resulting effects on regional groundwater flow patterns. As discussed above, there is no feasible mitigation available to address this significant impact. The impact would be considered significant and unavoidable in these areas.

Impact GW-10: Result in Groundwater Level–Induced Land Subsidence

See Impact GW-10 under Alternative 1A.

7.3.3.12 Alternative 6B—Isolated Conveyance with East Alignment and Intakes 1–5 (15,000 cfs; Operational Scenario D)

Facilities construction under Alternative 6B would be similar to that described for Alternative 1B. The different operational scenario under Alternative 6B would be reflected in changes in groundwater conditions in the Export Service Areas.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1B; construction activities under Alternative 6B would be identical to those under Alternative 1B.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1B; construction activities under Alternative 6B would be identical to those under Alternative 1B.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1B; construction activities under Alternative 6B would be identical to those under Alternative 1B.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1B; construction activities under Alternative 6B would be identical to those under Alternative 1B.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1B; construction activities under Alternative 6B would be identical to those under Alternative 1B.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 6B would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 6B would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-8 under Alternative 6A; project operations under Alternative 6B would be identical to those under Alternative 6A.

Impact GW-9: Degrade Groundwater Quality

See Impact GW-9 under Alternative 6A; project operations under Alternative 6B would be identical to those under Alternative 6A.

Impact GW-10: Result in Groundwater Level-Induced Land Subsidence

See Impact GW-10 under Alternative 6A; project operations under Alternative 6B would be identical to those under Alternative 6A.

7.3.3.13 Alternative 6C—Isolated Conveyance with West Alignment and Intakes W1–W5 (15,000 cfs; Operational Scenario D)

Facilities construction under Alternative 6C would be similar to that described for Alternative 1C. The different operational scenario under Alternative 6C would be reflected in changes in groundwater conditions in the Export Service Areas.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1C; construction activities under Alternative 6C would be identical to those under Alternative 1C.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1C; construction activities under Alternative 6C would be identical to those under Alternative 1C.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1C; construction activities under Alternative 6C would be identical to those under Alternative 1C.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1C; construction activities under Alternative 6C would be identical to those under Alternative 1C.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1C; construction activities under Alternative 6C would be identical to those under Alternative 1C.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 6C would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 6C would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-8 under Alternative 6A; project operations under Alternative 6C would be identical to those under Alternative 6A.

Impact GW-9: Degrade Groundwater Quality

See Impact GW-9 under Alternative 6A; project operations under Alternative 6C would be identical to those under Alternative 6A.

Impact GW-10: Result in Groundwater Level-Induced Land Subsidence

See Impact GW-10 under Alternative 6A; project operations under Alternative 6C would be identical to those under Alternative 6A.

7.3.3.14 Alternative 7—Dual Conveyance with Pipeline/Tunnel, Intakes 2, 3, and 5, and Enhanced Aquatic Conservation (9,000 cfs; Operational Scenario E)

Facilities construction under Alternative 7 would be similar to those described for Alternative 1A with only three intakes.

Operations under Alternative 7 would be similar to those under Alternative 1A except for the actions described in Chapter 6, *Surface Water*.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1A; construction activities under Alternative 7 would be similar to those under Alternative 1A. The impacts on groundwater levels resulting from dewatering activities are dependent on the local hydrogeology and the depth and duration of dewatering required. Because all of the pump stations associated with the intakes are located in areas of similar geology and hydrogeology, and the dewatering configurations are identical for each of the facilities, it would be expected that the impacts of construction activities on local groundwater levels and associated well yields would be similar. The only difference would be associated with the number of intakes used. This alternative would use intakes instead of five used in Alternative 1A. This would result in decreased dewatering impacts and fewer wells being affected.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1A; operations activities under Alternative 7 would be similar to those under Alternative 1A. Both alternatives use the same forebay locations, which, in the absence of design features intended to minimize seepage, would be the main locations of potential effects to groundwater levels.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1A; construction and operations activities under Alternative 7 would be similar to those under Alternative 1A, but to a lesser magnitude, since only three intakes would be constructed.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1A; construction activities under Alternative 7 would be similar to those under Alternative 1A, but to a lesser magnitude, because only three intakes would be constructed.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1A; operations activities under Alternative 7 would be similar to those under Alternative 1A.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 7 would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 7 would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

SWP/CVP deliveries to the Export Service Areas under Alternative 7 would be almost identical to those under Alternative 6A (see Chapter 5, *Water Supply*, and Table 7-7). Therefore, effects on groundwater levels under Alternative 7 are anticipated to be in the same range as those under Alternative 6A.

See Impact GW-8 under Alternative 6A.

Impact GW-9: Degrade Groundwater Quality

See Impact GW-9 under Alternative 6A.

Impact GW-10: Result in Groundwater Level–Induced Land Subsidence

See Impact GW-10 under Alternative 1A.

7.3.3.15 Alternative 8—Dual Conveyance with Pipeline/Tunnel, Intakes 2, 3, and 5, and Increased Delta Outflow (9,000 cfs; Operational Scenario F)

Facilities construction under Alternative 8 would be similar to that described for Alternative 1A with only three intakes.

Operations under Alternative 8 would be similar to those under Alternative 1A except for the actions described in Chapter 6, *Surface Water*.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-1 under Alternative 1A; construction activities under Alternative 8 would be similar to those under Alternative 1A. The impacts on groundwater levels resulting from dewatering activities are dependent on the local hydrogeology and the depth and duration of dewatering required. Because all of the pump stations associated with the intakes are located in areas of similar geology and hydrogeology, and the dewatering configurations are identical for each of the facilities, it would be expected that the impacts of construction activities on local groundwater levels and associated well yields would be similar. The only difference would be associated with the number of intakes used. This alternative would use three intakes instead of five used in Alternative 1A. This would result in decreased dewatering effects and fewer wells being affected.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

See Impact GW-2 under Alternative 1A; operations activities under Alternative 8 would be similar to those under Alternative 1A. Both alternatives would use the same forebay locations, which, in the absence of design features intended to minimize seepage, would be the main locations of potential effects to groundwater levels.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

See Impact GW-3 under Alternative 1A; construction and operations activities under Alternative 8 would be similar to those under Alternative 1A, but to a lesser magnitude, because only three intakes would be constructed.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-4 under Alternative 1A; construction activities under Alternative 8 would be similar to those under Alternative 1A, but to a lesser magnitude, because only three intakes would be constructed.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

See Impact GW-5 under Alternative 1A; operations activities under Alternative 8 would be similar to those under Alternative 1A.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 8 would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 8 would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: Total long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 8 would be less than under the No Action Alternative, as described in Chapter 5, *Water Supply*, and Table 7-7. Decreases in surface water deliveries attributable to project operations from the implementation of Alternative 8 are anticipated to result in a corresponding increase in groundwater use in the Export Service Areas, as compared with the No Action Alternative as discussed in Section 7.3.3.2.

CVHM modeling results show that Alternative 8 is forecasted to result in groundwater level declines beneath the Corcoran Clay of up to 25 feet in most areas but could exceed 250 feet under WBS 14 (i.e., Westside and Northern Pleasant Valley basins of the western Tulare Basin). The maximum groundwater level changes are forecasted to occur in August because agricultural groundwater pumping is typically highest in this month.

The forecasted groundwater level decreases across the San Joaquin and Tulare Basins during a typical peak groundwater level change condition in August, as compared with the No Action Alternative, are shown in Figure 7-34. These forecasted changes in groundwater levels result from increased agricultural pumping during the irrigation season because of a decrease in surface water deliveries from the Delta under Alternative 8.

Overall, the CVP and SWP deliveries to agricultural areas in the San Joaquin and Tulare Service Areas under this alternative would be less than for the No Action Alternative. The sustainable yield of some wells might be affected by the lower water levels such that they are not able to support the existing or planned land uses for which permits have been granted. The increase in groundwater pumping would cause an adverse effect on groundwater levels and associated well yields.

Alternative 8 is also forecasted to decrease the surface water supplies from the Delta to Export Service Areas outside of the Central Valley. If less surface water is available for municipal, industrial, and agricultural users, utilization of groundwater resources could increase (see Chapter 5, *Water Supply*). However, in the Central Coast and Southern California, overdrafted basins have, for the most part, been adjudicated to control the amount of pumping, thus reducing the amount of groundwater resource availability.

Many groundwater basins in the San Francisco Bay Area, Central Coast, and Southern California rely on SWP/CVP surface water to recharge groundwater basins (as described in Section 7.1.1.4). Therefore, adverse effects on groundwater supplies, groundwater recharge, and local groundwater table levels are expected to result from the implementation of Alternative 8 in these Export Service Areas.

Feasible mitigation would not be available to diminish this effect due to a number of factors. First, State and federal Water Contractors currently and traditionally have received variable water supplies under their contracts with DWR and Reclamation due to variations in hydrology and regulatory constraints and are accustomed to responding accordingly. Any reductions associated with this impact would be subject to these contractual limitations. Under standard state and federal water contracts, the risk of shortfalls in exports is borne by the contractors rather than DWR or Reclamation. As a result of this variability, many of the water contractors in water districts have complex water management strategies that include numerous options to supplement CVP and SWP surface water supplies. As discussed in Appendix 5B, *Responses to Reduced South of Delta Water Supplies*, adverse effects might be avoided due to the existence of various other water management options that could be undertaken in response to reduced exports from the Delta. In urban areas, these options include wastewater recycling and reuse, increased water conservation, water transfers, construction of new local reservoirs that could retain rainfall during wet years, and desalination in coastal areas. In agricultural areas, options for responding to reduced exports include changes in cropping patterns, improvements in irrigation efficiency, water transfers, and development of new local supplies. In both rural and urban areas, the affected water districts or individual water users are in the best position to determine the appropriate response to reduced deliveries from the Delta. Second, in adjudicated groundwater basins, it may be legally impossible to extract additional groundwater without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights. Finally, in many groundwater basins in the Central Coast and Central Valley, additional groundwater pumping might exacerbate existing overdraft and subsidence conditions, even if such pumping is legally permissible because the affected basin has not been adjudicated or no other groundwater management program is in place.

CEQA Conclusion: Total long-term average annual surface water deliveries to the CVP and SWP Service Areas under Alternative 8 would be less than under Existing Conditions in the San Joaquin and Tulare export service areas. As a result, modeling predicts that groundwater pumping under Alternative 8 would be greater than under Existing Conditions, and that groundwater levels in some areas would be lower than under Existing Conditions.

CVHM modeling results show that Alternative 8 would result in groundwater level declines beneath the Corcoran Clay (Central Valley) of up to 25 feet in most areas; declines could exceed 250 feet in the Westside and Northern Pleasant Valley basins of the western Tulare Lake Basin (Figure 7-35). On the eastern side of the San Joaquin and Tulare Lake basins, climate change effects on stream flows could result in a decline in groundwater levels by as much as 50 feet. In addition, if reduced stream flows are not adequate to meet the surface water diversion requirements, groundwater pumping might increase, resulting in a further decline in groundwater level. However, effects due to climate change would occur independently of the BDCP. The anticipated effects of climate change are provided for informational purposes only, but do not lead to mitigation measures.

Decreased groundwater levels associated with increased overall groundwater use under Alternative 8 could result in significant impacts in most of the Export Service Areas and significantly impact the yield of domestic, municipal and agricultural wells, such that they are not able to support the existing or planned land uses for which permits have been granted. As discussed above in the NEPA conclusion there is no feasible mitigation available to address this impact. Therefore, the impact would be considered significant and unavoidable.

Impact GW-9: Degrade Groundwater Quality

NEPA Effects: As discussed under Impact GW-8, the increase in groundwater pumping that could occur in portions of the Export Service Areas in response to reduced SWP/CVP water supply availability could alter regional patterns of groundwater flow and induce the migration of poor-quality groundwater into areas of good-quality groundwater, especially in the coastal areas of central Coast and southern California, where seawater intrusion has occurred in the past. For the same reasons discussed earlier, there is no feasible mitigation available to mitigate any changes in regional groundwater quality. This effect is considered adverse.

CEQA Conclusion: Alternative 8 could induce the degradation of groundwater quality in some areas due to the possibility of increased groundwater pumping and the resulting effects on regional groundwater flow patterns. As discussed above, there is no feasible mitigation available to address this significant impact. The impact would be considered significant and unavoidable in these areas.

Impact GW-10: Result in Groundwater Level-Induced Land Subsidence

See Impact GW-10 under Alternative 1A.

7.3.3.16 Alternative 9—Through Delta/Separate Corridors (15,000 cfs; Operational Scenario G)

Facilities constructed under Alternative 9 would include two fish-screened intakes along the Sacramento River near Walnut Grove, 14 operable barriers, two pumping plants and other associated facilities, two culvert siphons, three alignment segments, new levees, and new channel connections. Some existing channels would also be enlarged under this alternative. Nearby areas would be altered as work or staging areas or used for the deposition of spoils.

Alternative 9 does not include north Delta intakes. Instead, water would continue to flow by gravity from the Sacramento River into two existing channels, Delta Cross Channel and Georgiana Slough. Alternative 9 would operate in a manner more similar to the No Action Alternative with operational criteria related to minimizing reverse flows in Old and Middle Rivers applying only to Middle River and not including San Joaquin River export/inflow ratio criteria.

Delta Region

Impact GW-1: During Construction, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: Construction activities would take place primarily within the stream channels and in the shallow subsurface. The construction of on-bank diversions on Georgiana Slough and the Delta Cross-Channel, and the addition of channel sections, would likely require groundwater dewatering and would temporarily and locally affect groundwater levels as a result. The construction of a pumping plant on the San Joaquin River at the Head of Old River and a pumping plant on Middle River upstream of Victoria Canal would also require potentially substantial dewatering activities. During the dewatering period and for a short time thereafter, localized groundwater level drawdown is anticipated. While detailed dewatering activities and effects are not available, the effect on local shallow groundwater levels and nearby shallow well yields would be considered adverse. Mitigation Measure GW-1 is available to address this effect.

CEQA Conclusion: Construction activities related to temporary dewatering and associated reduced groundwater levels have the potential to temporarily affect the productivity of existing nearby water supply wells. This impact is considered significant. Implementation of Mitigation Measure GW-1 would reduce this impact to a less-than-significant level.

Mitigation Measure GW-1: Maintain Water Supplies in Areas Affected by Construction Dewatering

Please see Mitigation Measure GW-1 under Impact GW-1 in the discussion of Alternative 1A.

Impact GW-2: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects: Alternative 9 is not anticipated to cause substantial effects on groundwater levels and recharge in the Delta Region because the primary changes to the existing system would consist of re-routing surface water through various existing canals and streams through operable gates. New, small canal sections and channel connections would be operated with this alternative, but groundwater effects would not be substantial. It is not anticipated that Alternative 9 would create adverse effects on domestic and municipal well yields. The operation of the additional infrastructure, such as small canal sections and operable barriers in streams is not anticipated to cause adverse effects on groundwater well yields.

CEQA Conclusion: Under Alternative 9, operation of the additional infrastructure, such as small canal sections and operable barriers in streams, is not anticipated to deplete groundwater supplies or interfere with groundwater recharge, alter local groundwater levels, or reduce the production capacity of preexisting nearby wells. This impact is considered less than significant. No mitigation is required.

Impact GW-3: Degrade Groundwater Quality during Construction and Operation of Conveyance Facilities

NEPA Effects: Groundwater flow patterns are not expected to change under Alternative 9 construction and implementation. Therefore, there is no potential for poor-quality groundwater to migrate under this alternative. There would be no change to groundwater quality due to the construction and operation of Alternative 9, and no adverse effect.

CEQA Conclusion: Under Alternative 9, construction and operation of the additional infrastructure, such as small canal sections and operable barriers in streams, is not anticipated to degrade groundwater quality. This impact is considered less than significant. No mitigation is required.

Impact GW-4: During Construction of Conveyance Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: Construction activities will take place primarily within the stream channels and in the shallow subsurface, so no substantial dewatering activities are anticipated and there should be no substantial effects on groundwater flow and agricultural drainage in the main Delta areas. The construction of on-bank diversions on Georgiana Slough and the Delta Cross Channel, and the addition of channel sections, will likely require groundwater dewatering and thus will temporarily and locally affect groundwater levels. The construction of a pumping plant on the San Joaquin River at the Head of Old River and a pumping plant on Middle River upstream of Victoria Canal will also require potentially substantial dewatering activities. During the dewatering period and for a short time thereafter, localized groundwater flow and agricultural drainage disturbances are anticipated. The effect on agricultural drainage during construction is considered to be adverse. Mitigation Measure GW-5 is available to address this effect.

CEQA Conclusion: Under Alternative 9, construction activities related to temporary dewatering and associated changes in groundwater flow patterns have the potential to affect agricultural drainage nearby. This impact is considered significant. Implementation of Mitigation Measure GW-5 would reduce this impact to a less-than-significant level.

Mitigation Measure GW-5: Agricultural Lands Seepage Minimization

Please see Mitigation Measure GW-5 under Impact GW-5 in the discussion of Alternative 1A.

Impact GW-5: During Operations of New Facilities, Interfere with Agricultural Drainage in the Delta

NEPA Effects: Operation of facilities under Alternative 9 is not anticipated to cause adverse effects on groundwater flow and agricultural drainage in the Delta Region. The new, small canal sections and channel connections could result in localized effects on groundwater flow and agricultural drainage. However, no regional affects are anticipated to occur. No interference with agricultural drainage is anticipated.

CEQA Conclusion: Alternative 9 is not anticipated to cause significant impacts on groundwater flow and agricultural drainage in the Delta Region. The new, small canal sections and channel connections could result in very localized impacts to groundwater flow and agricultural drainage. However, no regional impacts are anticipated to occur. This impact is considered less than significant. No mitigation is required.

Impact GW-6: Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Local Groundwater Levels, Reduce the Production Capacity of Preexisting Nearby Wells, or Interfere with Agricultural Drainage as a Result of Implementing CM2–CM22

See Impact GW-6 under Alternative 1A; CM2–CM22 under Alternative 9 would result in effects similar to those under Alternative 1A.

Impact GW-7: Degrade Groundwater Quality as a Result of Implementing CM2–CM22

See Impact GW-7 under Alternative 1A; CM2–CM22 under Alternative 9 would result in effects similar to those under Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-8: During Operations, Deplete Groundwater Supplies or Interfere with Groundwater Recharge, Alter Groundwater Levels, or Reduce the Production Capacity of Preexisting Nearby Wells

NEPA Effects:

Total long-term average annual water deliveries to the CVP and SWP Service Areas under Alternative 9 would be similar to those under the No Action Alternative, as described in Chapter 5, *Water Supply*, and Table 7-7. Periodic decreases in surface water deliveries attributable to project operations from the implementation of Alternative 9 are anticipated to result in a corresponding increase in groundwater use in the Export Service Areas, as compared with the No Action Alternative as discussed in Section 7.3.3.2.

CVHM modeling results show that groundwater levels would decrease by up to 100 feet beneath the Corcoran Clay under WBS 14 (i.e., Westside and Northern Pleasant Valley basins). The forecasted maximum groundwater level changes occur in dry years in August because agricultural groundwater pumping is typically highest during this month.

The forecasted groundwater level declines across the Export Service Areas during a typical peak groundwater level change condition in August, as compared with the No Action Alternative, are shown in Figure 7-36.

Overall, the CVP and SWP deliveries to agricultural areas in the San Joaquin and Tulare Service Areas under this alternative would be less than for the No Action Alternative. The sustainable yield of some wells might be affected by the lower water levels such that they are not able to support the existing or planned land uses for which permits have been granted. The increase in groundwater pumping would cause an adverse effect on groundwater levels and associated well yields. Under Alternative 9, SWP deliveries to Southern California areas would be less than those under the No Action Alternative. Implementation of Alternative 9 could result in an overall increase in groundwater pumping and a corresponding decrease in groundwater levels; therefore creating an adverse impact on groundwater resources. However, in the Central Coast and Southern California, overdrafted basins have, for the most part, been adjudicated to control the amount of pumping, thus reducing the amount of groundwater resource availability.

Feasible mitigation would not be available to diminish this effect due to a number of factors. First, State and federal Water Contractors currently and traditionally have received variable water supplies under their contracts with DWR and Reclamation due to variations in hydrology and regulatory constraints and are accustomed to responding accordingly. Any reductions associated with this impact would be subject to these contractual limitations. Under standard state and federal water contracts, the risk of shortfalls in exports is borne by the contractors rather than DWR or Reclamation. As a result of this variability, many of the water contractors in water districts have complex water management strategies that include numerous options to supplement CVP and SWP surface water supplies. As discussed in Appendix 5B, *Responses to Reduced South of Delta Water Supplies*, adverse effects might be avoided due to the existence of various other water management options that could be undertaken in response to reduced exports from the Delta. In urban areas, these options include wastewater recycling and reuse, increased water conservation, water transfers, construction of new local reservoirs that could retain rainfall during wet years, and desalination in coastal areas. In agricultural areas, options for responding to reduced exports include changes in cropping patterns, improvements in irrigation efficiency, water transfers, and development of new local supplies. In both rural and urban areas, the affected water districts or individual water users are in the best position to determine the appropriate response to reduced deliveries from the Delta. Second, in adjudicated groundwater basins, it may be legally impossible to extract additional groundwater without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights. Finally, in many groundwater basins in the Central Coast and Central Valley, additional groundwater pumping might exacerbate existing overdraft and subsidence conditions, even if such pumping is legally permissible because the affected basin has not been adjudicated or no other groundwater management program is in place.

CEQA Conclusion: Total long-term average annual surface water deliveries to the CVP and SWP Service Areas under Alternative 9 would be less than under Existing Conditions in the San Joaquin and Tulare export service areas. As a result, modeling predicts that groundwater pumping under Alternative 9 would be greater than under Existing Conditions, and that groundwater levels in some areas would be lower than under Existing Conditions. CVHM modeling results show that Alternative 9 would result in groundwater level declines beneath the Corcoran Clay (Central Valley) of up to 25 feet in most areas; declines could exceed 250 feet in the Westside and Northern Pleasant Valley basins of the western Tulare Lake Basin (Figure 7-37). On the eastern side of the San Joaquin and Tulare Lake basins, climate change effects on stream flows could result in a decline in groundwater levels by as much as 50 feet. In addition, if reduced stream flows are not adequate to meet the surface water diversion requirements, groundwater pumping might increase, resulting in a further decline in groundwater level. However, effects due to climate change would occur independently of the BDCP. The anticipated effects of climate change are provided for informational purposes only, but do not lead to mitigation measures.

Decreased groundwater levels associated with increased overall groundwater use under Alternative 9 could result in significant impacts in most of the Export Service Areas and significantly impact the yield of domestic, municipal and agricultural wells, such that they are not able to support the existing or planned land uses for which permits have been granted. As discussed above in the NEPA conclusion there is no feasible mitigation available to address this impact. Therefore, the impact would be considered significant and unavoidable.

Impact GW-9: Degrade Groundwater Quality

NEPA Effects: As discussed under Impact GW-8, the increase in groundwater pumping that could occur in portions of the Export Service Areas in response to reduced CVP water supply availability could alter regional patterns of groundwater flow and induce the migration of poor-quality groundwater into areas of good-quality groundwater, especially in the coastal areas of central Coast and southern California, where seawater intrusion has occurred in the past. For the same reasons discussed earlier, there is no feasible mitigation available to mitigate any changes in regional groundwater quality. This effect is considered adverse.

CEQA Conclusion: Implementation of Alternative 9 could induce the degradation of groundwater quality in portions of the Export Service Areas due to the possibility of increased groundwater pumping and the resulting effects on regional groundwater flow patterns. As discussed above, there is no feasible mitigation available to address this significant impact. The impact would be considered significant and unavoidable in these areas.

Impact GW-10: Result in Groundwater Level–Induced Land Subsidence

The potential for groundwater level-induced land subsidence under Alternative 9 would be similar to that under Alternatives 1A and 6A. See Impact GW-10 under Alternative 1A.

7.3.4 Cumulative Analysis

Cumulative effects result from incremental impacts of a proposed action when added with other past, present, and reasonably foreseeable future actions. This section identifies the potential for past, present and reasonably foreseeable future programs, projects, and policies to cause adverse cumulative impacts on groundwater resources in the Delta Region and the Export Service Areas south of the Delta.

When the effects of any of the BDCP alternatives are considered in combination with the effects of initiatives listed in Table 7-8, the cumulative effects on groundwater resources could be adverse. The specific programs, projects and policies are identified below for each impact category based on the potential to contribute to a BDCP impact that could be deemed cumulatively considerable. The potential for cumulative impacts on groundwater resources is described for effects related to the construction of water conveyance facilities and effects stemming from the long-term implementation of CM2–22.

All of the BDCP alternatives included the assumption that the following programs identified to occur under the No Project Alternative and No Action Alternative were implemented.

- Grasslands Bypass Project.
- Lower American River Flow Management Standard (simulated in Existing Conditions, No Action Alternative, and all Alternatives).
- Delta-Mendota Canal / California Aqueduct Intertie.
- Freeport Regional Water Project.

Therefore, the effects of those projects were included in the water supply operations presented in Chapter 5, *Water Supply*, and the associated groundwater resources effects analysis are presented in previous subsections of this chapter through the comparison of BDCP alternatives and the No Action Alternative.

The Cumulative Analysis for groundwater resources includes a comparison of conditions that could occur without the BDCP alternatives with conditions that could occur with implementation of the BDCP alternatives to determine if the combined effect of implementation of all of these projects could be cumulatively significant, and if so, whether the incremental effect of the BDCP alternatives could be considered cumulatively considerable.

The following list presented in Table 7-8 includes projects considered for this cumulative effects section; for a complete list of such projects, consult Appendix 3D, *Defining Existing Conditions, No Action Alternative, No Project Alternative, and Cumulative Impact Conditions*. Several projects that are included in Table 3D-5 for the Cumulative Impact Assessment might have had construction impacts on groundwater resources, but they have been completed, and therefore were not included in this analysis.

Table 7-8. Effects on Groundwater Resources from the Plans, Policies, and Programs Considered for Cumulative Analysis

Agency	Program/ Project	Status	Description of Program/Project	Effects on Groundwater Resources
California Department of Water Resources	North Delta Flood Control and Ecosystem Restoration Project	Final EIR completed in 2010	Project implements flood control and ecosystem restoration benefits in the north Delta (California Department of Water Resources 2010c)	Potential increase in groundwater levels and groundwater recharge; potential groundwater seepage to adjacent islands/tracts; potential groundwater contamination
California Department of Water Resources	Dutch Slough Tidal Marsh Restoration Project	Program under development. Draft Plan and EIR in 2008. Final EIR in 2010.	Project includes breaching levees and restoring a tidal channel system on parcels between Dutch Slough and Contra Costa Canal (California Department of Water Resources 2010d)	Potential groundwater intrusion onto adjacent parcels
Contra Costa Water District, Bureau of Reclamation, and California Department of Water Resources	Los Vaqueros Reservoir Expansion Project	Program under development. Draft EIS/EIR in 2009. Final EIS/EIR in 2010. Estimated completion in 2012.	Project will increase the storage capacity of Los Vaqueros Reservoir and divert additional water from the Delta	First phase is being constructed. The second phase has been evaluated in an environmental impact report/environmental impact statement that indicate no adverse effects or less than significant effects on groundwater resources
Northeastern San Joaquin County Groundwater Banking Authority	Eastern San Joaquin Integrated Conjunctive Use Program	Program under development. Final Programmatic EIR in 2009	Program will improve the use and storage of groundwater by implementing conjunctive use projects such as water transfers and groundwater banking	Affect groundwater level fluctuations due to groundwater banking operations; potential groundwater quality impacts; mostly beneficial effects; the effects would be located outside of the BDCP conveyance footprint area

Agency	Program/ Project	Status	Description of Program/Project	Effects on Groundwater Resources
Bureau of Reclamation, San Luis & Delta Mendota Water Authority	Grassland Bypass Project, 2010–2019, and Agricultural Drainage Selenium Management Program	Program under development. Final EIS/EIR in 2009	Reduce effects from agricultural drainage on wildlife refuges and wetlands. Will convey subsurface agricultural drainage to Mud Slough (tributary of San Joaquin River) (Bureau of Reclamation and San Luis & Delta-Mendota Water Authority 2008)	Beneficial, neutral, or less-than-significant effects on subsurface agricultural drainage and shallow groundwater levels; beneficial effects on groundwater salinity
Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Services, Department of Water Resources, and Department of Fish and Wildlife	San Joaquin River Restoration Program	Final EIS/EIR completed in 2012.	The San Joaquin River Restoration Program is a direct result of a September 2006 legal settlement by the U.S. Departments of the Interior and Commerce, the Natural Resources Defense Council, and the Friant Water Users Authority to restore spring and fall run Chinook salmon to the San Joaquin River below Friant Dam while supporting water management actions within the Friant Division. Public Law 111-11 authorized and directed federal agencies to implement the settlement. Interim flows began October 1, 2009, and full restoration flows are scheduled to begin no later than January 2014 (California Department of Water Resources 2009:SJ-12).	Temporary Construction-Related Effects on Groundwater Quality; changes in groundwater levels and groundwater quality along San Joaquin River; changes in groundwater levels and groundwater quality in CVP/SWP service areas

All of these projects have completed draft or final environmental documents that analyzed their potential impacts on groundwater resources. According to these documents, the impacts on groundwater resources would be less than significant or less than significant after mitigation measures are implemented.

The first four projects listed are located in or around the Delta Region. The last two projects listed are located in the SWP/CVP Export Service Areas. The cumulative effects will be discussed separately for the two regions.

No Action Alternative

Changes in Delta Groundwater Levels

Groundwater levels in the Delta for the No Action Alternative would be strongly influenced by surface water flows in the Sacramento River that fluctuate due to sea level rise, climate change and due to surface water operations. Similar effects related to these factors would also occur under the action alternatives.

Compared with Existing Conditions, forecasted groundwater levels would increase by up to 5 feet in the Suisun Marsh area in the No Action Alternative; the cumulative increase is due to sea level rise in San Francisco Bay. This incremental increase in groundwater level in the No Action Alternative is not expected to cause cumulative effects on nearby well yields. In other areas of the Delta, groundwater levels would be similar under Existing Conditions as compared to the No Action Alternative.

Changes in Delta Groundwater Quality

As described above, groundwater levels would be similar under Existing Conditions and the No Action Alternative except for a localized area around Suisun Marsh. Therefore, cumulative changes in groundwater conditions under the No Action Alternative are not anticipated to alter regional patterns of groundwater flow or quality, compared with Existing Conditions. Minor cumulative groundwater quality effects due to seawater intrusion might occur; however, no groundwater salinity simulations are available to verify this hypothesis.

Changes in Delta Agricultural Drainage

Due to fluctuations in groundwater levels that occur with sea level rise and climate change, some areas of the Delta might experience rises in groundwater levels in the vicinity of rivers and in the Suisun Marsh area under the No Action Alternative compared to Existing Conditions. Similar effects related to these factors would also occur under the action alternatives. This could affect agricultural drainage. However, cumulative changes are anticipated to be minor and these areas would be surrounded by larger regional flow patterns that would remain largely unchanged under the No Action Alternative.

SWP/CVP Export Service Areas

Under the No Action Alternative, surface water supplies to the Export Service Areas would continue to exhibit a cumulative decline based on water modeling and operational assumptions described in Chapters 5 and 6 which project reductions in SWP/CVP water supply availability, compared to Existing Conditions. In addition, cumulative decreases in SWP/CVP surface water deliveries in the Export Service Areas for the No Action Alternative compared to Existing Conditions also occur due to sea level rise and climate change, as described in Chapter 5, *Water Supply*. Similar effects related to these factors would also occur under the action alternatives.

BDCP Alternatives

Delta Region

Impact GW-1: Cumulative Depletion of Groundwater Supplies or Interference with Groundwater Recharge, Alteration of Local Groundwater Levels, or Reduction in the Production Capacity of Preexisting Nearby Wells, as a Result of Construction and Operation of the Proposed Conveyance Facilities

NEPA Effects: Construction dewatering activities associated with each BDCP alternative would result in temporary altered groundwater levels and associated potential decreases in well yields. The sustainable yield of some wells might temporarily be affected by the lower water levels such that they are not able to support the existing land uses. Alternatives 1B, 1C, 2B, 2C, 6B, and 6C, which include canals as conveyance options, have a larger construction impact footprint. In addition, the

BDCP alternatives that include canal options might trigger groundwater discharge into some canal sections (mostly the unlined option), and locally lower groundwater levels by approximately up to 10 feet, which could reduce the sustainable yield of shallow wells and affect associated land uses.

Other projects that would potentially affect groundwater levels and well yields through construction dewatering have been or are being completed. Implementing these projects in combination with any of Alternatives 1A though 9 would result in cumulative adverse effects. Mitigation Measure GW-1 would be available to reduce those effects created by BDCP-related activities.

CEQA Conclusion: Construction dewatering activities associated with each BDCP alternative would result in temporary decreases in groundwater levels and associated well yields. Ongoing operations associated with the canal alignments would result in long-term discharge of groundwater to some canal sections. Other projects that would potentially affect groundwater levels and well yields through construction dewatering have been or are being completed. Implementing these projects in combination with any of BDCP Alternatives 1A though 9 would result in significant cumulative impacts. Mitigation Measure GW-1 identifies a monitoring procedure and options for maintaining an adequate water supply for land owners that experience a reduction in groundwater production from wells within 2,600 feet of construction-related dewatering activities. Implementing Mitigation Measure GW-1 would help address these effects; however, the impact may remain significant because replacement water supplies may not meet the preexisting demands or planned land use demands of the affected party. In some cases the BDCP-related impact might temporarily be cumulatively considerable and unavoidable until groundwater elevations recover to preconstruction conditions, which could require several months after dewatering operations cease.

Mitigation Measure GW-1: Maintain Water Supplies in Areas Affected by Construction Dewatering

Please see Mitigation Measure GW-1 under Impact GW-1 in the discussion of Alternative 1A.

Impact GW-2: Cumulative Degradation of Groundwater Quality as a Result of Construction and Operation of the Proposed Conveyance Facilities

NEPA Effects: Construction and ongoing operations associated with each BDCP alternative would not substantially alter regional groundwater flow patterns and therefore would not change the quality of groundwater in the locally affected areas. Other projects that would potentially alter groundwater quality are listed in Table 7-8. The North Delta Flood Control and Ecosystem Restoration Project would have a less-than-significant effect on groundwater quality. None of these projects are anticipated to alter groundwater flow and quality. Implementing these projects in combination with any of Alternatives 1A though 9 would not result in cumulative adverse effects.

CEQA Conclusion: Construction and ongoing operations associated with each BDCP alternative would not substantially alter regional groundwater flow patterns and therefore would not change the quality of groundwater in the locally affected areas. None of the projects listed in Table 7-8 would affect groundwater flow and quality. Therefore, implementing these projects in combination with any of the BDCP Alternatives 1A through 9 would not result in a significant cumulative impact. The incremental contribution to this impact of any of BDCP Alternatives 1A though 9 would not be cumulatively considerable.

Impact GW-3: Cumulative Interference with Agricultural Drainage in the Delta, as a Result of Construction and Operation of the Proposed Conveyance Facilities

NEPA Effects: Construction dewatering activities associated with each BDCP alternative might temporarily and locally alter flow patterns near the dewatering centers; however, they are not anticipated to cause any significant effects on agricultural drainage. Ongoing operations of the BDCP alternatives would alter groundwater flow patterns and groundwater levels in the vicinity of some canal segments. Operation of forebays is not expected to result in changes in groundwater flow patterns on adjacent lands. The Intermediate and Byron Tract Forebays, as well as the expanded Clifton Court Forebay under Alternative 4, would be constructed to comply with the requirements of the DSD which includes design provisions to minimize seepage. These design provisions would minimize seepage under the embankments and onto adjacent properties. Once constructed and placed in operation, the operation of the forebays would be monitored to ensure seepage does not exceed performance requirements. In the event seepage were to exceed these performance requirements, the BDCP proponents would modify the embankments or construct seepage collection systems that would ensure any seepage from the forebays would be collected and conveyed back to the forebay or other suitable disposal site. Constructing the forebays to DSD standards, monitoring for seepage, and making modifications to the forebays or constructing measures to attenuate seepage if it were to occur will ensure that existing agricultural drainage systems would not be adversely affected.

For Alternatives 1B, 1C, 2B, 2C, 6B, and 6C, however, some canal segments might lose water to the shallow aquifer, especially for the unlined canal option. The increase in groundwater levels might affect agricultural drainage in those areas, if current agricultural drainage systems are not adequate to accommodate the additional drainage requirements in the vicinity of these conveyance features. For other cases, in which the canal segments are gaining water from the surrounding aquifer, agricultural drainage might be improved.

Other projects that would potentially alter groundwater levels and agricultural drainage are listed in Table 7-8. Both the North Delta Flood Control and Ecosystem Restoration Project and the Dutch Slough Tidal Marsh Restoration Project have a potential for groundwater seepage onto adjacent islands or tracts of the Delta, which could impair local agricultural drainage. However, the EIRs associated with these projects report a less-than-significant impact after mitigation. Implementing these projects in combination with any of Alternatives 1B, 1C, 2B, 2C, 6B, or 6C would result in cumulative adverse effects. Mitigation Measure GW-5 would be available to reduce those effects created by BDCP-related activities.

***CEQA Conclusion*:** Construction dewatering activities associated with each BDCP alternative would not substantially affect agricultural drainage. However, ongoing operations associated with BDCP Alternatives 1B, 1C, 2B, 2C, 6B, or 6C would discharge water to the aquifer from some canal segments for the unlined canal options. Other projects that would potentially alter groundwater levels and agricultural drainage are listed in Table 7-8. None of these projects would have a significant effect on agricultural drainage after mitigation. Implementing these projects in combination with any of Alternatives 1B, 1C, 2B, 2C, 6B, or 6C would result in a significant cumulative impact and the incremental contribution to this impact of any of BDCP Alternatives 1B, 1C, 2B, 2C, 6B, or 6C would be cumulatively considerable. Mitigation Measure GW-5 would reduce the severity of impacts created by BDCP-related activities in most instances. Occasionally, however, mitigation may be determined infeasible and the impact would be considered unavoidable.

Mitigation Measure GW-5: Agricultural Lands Seepage Minimization

Please see Mitigation Measure GW-5 under Impact GW-5 in the discussion of Alternative 1A.

Impact GW-4: Cumulative Depletion of Groundwater Supplies or Interference with Groundwater Recharge, Alteration of Local Groundwater Levels, Reduction in the Production Capacity of Preexisting Nearby Wells, or Interference with Agricultural Drainage as a Result of Implementing CM2–CM22

NEPA Effects: Increased frequency of inundation of areas associated with the proposed tidal habitat, channel margin habitat, and seasonally inundated floodplain restoration actions would result in groundwater recharge which could in turn affect agricultural drainage in areas of shallow groundwater levels. Other projects that would potentially alter groundwater levels and agricultural drainage are listed in Table 7-8. As described for previous impacts, none of these projects will cause adverse effects on groundwater resources in the Delta after mitigation. Implementing these projects in combination with any of Alternatives 1A though 9 would result in cumulative adverse effects. Mitigation Measures GW-1 and GW-5 would be available to reduce those effects created by BDCP-related activities.

***CEQA Conclusion*:** Increased frequency of inundation of areas associated with the proposed restoration actions would result in groundwater recharge which could affect agricultural drainage in areas of shallow groundwater levels. Other projects that would potentially alter groundwater levels and agricultural drainage are listed in Table 7-8. None of these projects will cause significant effects on groundwater resources after mitigation. Implementing these projects in combination with any of Alternatives 1A though 9 would result in a significant cumulative impact and the incremental contribution to this impact of any of BDCP Alternatives 1A through 9 would be cumulatively considerable. Mitigation Measures GW-1 and GW-5 would be available to reduce the severity of impacts created by BDCP-related activities.

Mitigation Measure GW-1: Maintain Water Supplies in Areas Affected by Construction Dewatering

Please see Mitigation Measure GW-1 under Impact GW-1 in the discussion of Alternative 1A.

Mitigation Measure GW-5: Agricultural Lands Seepage Minimization

Please see Mitigation Measure GW-5 under Impact GW-5 in the discussion of Alternative 1A.

Impact GW-5: Cumulative Degradation of Groundwater Quality as a Result of Implementing CM2–CM22

NEPA Effects: Increased inundation frequency in restoration areas would increase the localized areas exposed to saline and brackish surface water, which could result in increased groundwater salinity beneath such areas. Other projects that would potentially affect groundwater quality are listed in Table 7-8. As described for previous impacts, none of these projects will cause adverse effects on groundwater resources in the Delta after mitigation. Implementing these projects in combination with any of Alternatives 1A though 9 would result in cumulative adverse effects on groundwater quality. Mitigation Measure GW-7 would be available to reduce those effects created by BDCP-related activities.

CEQA Conclusion: Increased inundation frequency in restoration areas would increase the localized areas exposed to saline and brackish surface water, which could result in increased groundwater salinity beneath such areas. Other projects that would potentially alter groundwater levels and agricultural drainage are listed in Table 7-8. None of these projects will cause significant effects on groundwater resources after mitigation. Implementing these projects in combination with any of Alternatives 1A though 9 would result in a significant cumulative impact and the incremental contribution to this impact of any of BDCP Alternatives 1A through 9 would be cumulatively considerable. Mitigation Measure GW-7 would be available to reduce the severity of impacts created by BDCP-related activities.

Mitigation Measure GW-7: Provide an Alternate Source of Water

Please see Mitigation Measure GW-7 under Impact GW-7 in the discussion of Alternative 1A.

SWP/CVP Export Service Areas

Impact GW-6: Cumulative Depletion of Groundwater Supplies or Interference with Groundwater Recharge, Alteration of Local Groundwater Levels, or Reduction in the Production Capacity of Preexisting Nearby Wells, as a Result of Operation of the Proposed Conveyance Facilities

NEPA Effects: Ongoing operations associated with each BDCP alternative could have effects on groundwater levels in the Export Service Areas. As described in Chapter 5, *Water Supply*, Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, and 5 could increase surface water deliveries to the service areas compared to the No Action Alternative, which could decrease groundwater pumping. The resulting increase in groundwater levels would be a beneficial effect.

Alternatives 4, 6A, 6B, 6C, 7, 8, and 9 could decrease surface water deliveries to the export service areas in most years (see Chapter 5, *Water Supply*) compared to the No Action Alternative, which could result in an increase in groundwater pumping as an alternative water supply source. This increase in groundwater pumping would cause a decrease in groundwater levels and associated well yields, such that existing and future land uses for which permits have been granted might be affected. Other projects that would potentially affect groundwater levels are listed in Table 7-8. The San Joaquin River Restoration Program would result in a decrease in surface water deliveries to Friant Division long-term contractors which would result in an increase in groundwater pumping and subsequent decrease in groundwater levels. This program could result in potentially significant and unavoidable effects on groundwater levels (Bureau of Reclamation 2011: 12-121). Implementing these projects in combination with any of Alternatives 1A through 9 could result in cumulative adverse effects on groundwater levels and associated well yields.

However, opportunities for additional pumping might be limited by basin adjudications and other groundwater management programs. Additionally, as discussed in Appendix 5B, *Responses to Reduced South of Delta Water Supplies*, adverse effects might be avoided due to the existence of various other water management options that could be undertaken in response to reduced exports from the Delta. These options include wastewater recycling and reuse, increased water conservation, water transfers, construction of new local reservoirs that could retain Southern California rainfall during wet years, and desalination.

Even if the effect is adverse, feasible mitigation would not be available to diminish this effect due to a number of factors. First, State Water Contractors currently and traditionally have received variable water supplies under their contracts with DWR due to variations in hydrology and regulatory constraints and are accustomed to responding accordingly. Any reductions associated with this impact would be subject to these contractual limitations. Under standard state water contracts, the risk of shortfalls in exports is borne by the contractors rather than DWR. As a result of this variability, many Southern California water districts have complex water management strategies that include numerous options, as described above, to supplement SWP surface water supplies. These water districts are in the best position to determine the appropriate response to reduced imports from the Delta. Second, as noted above, it may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights. Finally, in many groundwater basins, additional groundwater pumping might exacerbate existing overdraft and subsidence conditions, even if such pumping is legally permissible because the affected basin has not been adjudicated or no other groundwater management program is in place.

CEQA Conclusion: Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, and 5 could increase surface water deliveries to the service areas compared to Existing Conditions, which could decrease groundwater pumping. The resulting increase in groundwater levels would be a beneficial effect. Alternatives 4, 6A, 6B, 6C, 7, 8, and 9 could decrease surface water deliveries to the export areas in most years compared to Existing Conditions, which would result in an increase in groundwater pumping. This increase in groundwater pumping could cause a decrease in groundwater levels and associated well yields, such that existing and future land uses for which permits have been granted might be affected. Other projects that would potentially affect groundwater levels are listed in Table 7-8. Implementing these projects in combination with any of Alternatives 1A through 9 would result in a significant cumulative impact and the incremental contribution to this impact of any of BDCP alternatives would be cumulatively considerable. As described above, however, feasible mitigation would not be available to diminish this impact.

Impact GW-7: Cumulative Degradation of Groundwater Quality as a Result of Operation of the Proposed Conveyance Facilities

NEPA Effects: As previously described in the impacts analysis section, Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, and 5 would not result in a degradation of groundwater quality compared to the No Action Alternative. On the other hand, Alternatives 4, 6A, 6B, 6C, 7, 8, and 9 could induce additional groundwater pumping compared to the No Action Alternative and thus create the potential for a migration of poor-quality groundwater into areas of good quality groundwater, degrading local groundwater supplies. Other projects that would potentially affect groundwater levels are listed in Table 7-8. The San Joaquin River Restoration Program would result in a decrease in surface water deliveries to Friant Division long-term contractors which would result in an increase in groundwater pumping and a potential for upwelling of poorer quality groundwater. This program could result in potentially significant and unavoidable effects on groundwater quality (Bureau of Reclamation 2011: 12-122). Implementing these projects in combination with any of Alternatives 1A through 9 would result in cumulative adverse effects on groundwater quality. For the same reasons discussed earlier in connection with the possibility of increased groundwater pumping, there is no feasible mitigation available to mitigate any changes in regional groundwater quality.

CEQA Conclusion: Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, and 5 would increase surface water deliveries to the service areas compared to Existing Conditions, which would decrease groundwater pumping. The resulting increase in groundwater levels would be a beneficial effect. Alternatives 4, 6A, 6B, 6C, 7, 8, and 9 could decrease surface water deliveries to the export areas in most years compared to Existing Conditions, which would result in an increase in groundwater pumping. This increase in groundwater pumping would cause a decrease in groundwater levels and associated well yields, such that existing and future land uses for which permits have been granted might be affected. Other projects that would potentially affect groundwater levels are listed in Table 7-8. Implementing these projects in combination with any of Alternatives 1A through 9 would result in a significant cumulative impact and the incremental contribution to this impact of any of BDCP alternatives would be cumulatively considerable. For the same reasons discussed earlier in connection with the possibility of increased groundwater pumping, there is no feasible mitigation available to mitigate any changes in regional groundwater quality.

Impact GW-8: Cumulatively Result in Groundwater Level-Induced Land Subsidence

NEPA Effects: As previously described in the impacts analysis section, none of the BDCP alternatives would result in groundwater level-induced land subsidence. Other projects that would potentially affect groundwater level-induced land subsidence are listed in Table 7-8. None of these projects report a potential for inducing groundwater level-induced land subsidence as a significant effect. Implementing these projects in combination with any of Alternatives 1A through 9 would not result in cumulative adverse effects on groundwater level-induced land subsidence.

CEQA Conclusion: None of the BDCP alternatives would result in groundwater level-induced land subsidence. Other projects that would potentially affect groundwater level-induced land subsidence are listed in Table 7-8. None of these projects report a potential for inducing groundwater level-induced land subsidence as a significant effect. Implementing these projects in combination with any of Alternatives 1A through 9 would not result in cumulative significant effects on groundwater level-induced land subsidence. The incremental contribution to this impact of any of BDCP Alternatives 1A though 9 would not be cumulatively considerable.

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