Long-Term Operation – Final Environmental Impact Statement

Chapter 6 – Groundwater

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Chapter 6 Groundwater

This impact assessment is based on the background information and technical analysis documented in Appendix I, *Groundwater Technical Appendix*, which includes additional information on groundwater conditions and technical analysis of the effects of each alternative.

6.1 Affected Environment

Groundwater occurs throughout the study area. The groundwater resources that could be directly or indirectly affected through implementation of the alternatives analyzed in the EIS are related to groundwater basins where users of Central Valley Project (CVP) and State Water Project (SWP) water supplies also use groundwater, and areas along the rivers downstream of CVP or SWP reservoirs that use groundwater supplies. Changes in CVP and SWP operations may change groundwater resources in the Trinity River, Sacramento Valley (Sacramento River, American River), Clear Creek, San Joaquin Valley (Stanislaus River, San Joaquin River), and Sacramento–San Joaquin Delta (Delta) areas. The additional areas where CVP and SWP deliveries are exported (Central Coast and Southern California regions) are also included.

6.1.1 Overview

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

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

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

The importance of groundwater as a resource varies regionally. The Central Coast has the most reliance on groundwater to meet its local uses, with nearly 90% of the agricultural, municipal, and industrial water supplies by groundwater in an average year. The Sacramento Valley and northern portion of the San Joaquin Valley Groundwater Basin use groundwater to meet approximately 34% and 48% of the agricultural, municipal, and industrial water demand, respectively (California Department of Water Resources 2021b). On an annual average basis in the coastal areas of Southern California, groundwater use varies from less than 10% in western San Diego County to between 35% and 50% of the agricultural, municipal, and industrial water supplies in counties along the coast in western Ventura, Los Angeles, and Riverside counties and in Orange County. In the inland areas of Southern California, groundwater use varies from approximately 45% to over 90% of the agricultural, municipal, and industrial water supplies (California Department of Water Resources 2013b).

6.1.2 Trinity River

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

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

6.1.3 Sacramento River Valley

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

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

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

6.1.4 Clear Creek

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

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

6.1.5 San Joaquin Valley

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

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

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

6.1.6 Bay-Delta

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

6.1.7 Central Coast Region

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

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

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

6.1.8 Southern California Region

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

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

6.2 Methods and Tools

The impact assessment considers changes to groundwater related to changes in CVP and SWP operations under the alternatives compared to the No Action Alternative.

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

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

6.3 Effects of the Alternatives

The impact analysis considers changes in groundwater conditions related to changes in CVP and SWP operation under the alternatives as compared with the No Action Alternative.

The No Action Alternative is based on 2040 conditions. The changes to groundwater resources such as changes in groundwater pumping and potential changes in ground and surface water interaction flow that are assumed to occur by 2040 under the No Action Alternative conditions would be different than existing conditions because of the following factors:

- Climate change and sea-level rise

- General plan development throughout California, including increased water demands in portions of the Sacramento Valley

In the long term, it is anticipated that climate change, and development throughout California, could affect water supply deliveries.

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

Although the No Action Alternative included habitat restoration projects at a programmatic level, the 2020 ROD did not provide environmental coverage for these projects, and all of the habitat projects considered under the No Action required or will require additional environmental documentation. Thus, ground disturbance for habitat restoration projects did not materialize as a result of implementing the No Action Alternative. For the purpose of the analysis, these habitat restoration projects are considered independent projects that will be considered under cumulative effects.

The No Action Alternative is expected to result in potential changes to groundwater resources, such as groundwater pumping, elevation, and groundwater-surface water interaction flow. These changes were described and considered in the 2020 LTO Record of Decision and associated documents.

6.3.1 Potential Changes in Groundwater Pumping

6.3.1.1 Trinity River

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

6.3.1.2 Central Valley

Alternatives 1 through 4 would cause flow changes in the Sacramento River in Delta outflow requirements. Flow changes could affect surface water available for use by SWP and CVP contractors. *Chapter 5, Water Supply,* provides additional information on the extent and magnitude of changes to water supply. Changes in surface water supply deliveries may result in changes to groundwater pumping to offset the change in deliveries.

Groundwater pumping locations and amounts are typically not publicly available for inclusion in groundwater models; therefore, groundwater models of the region calculate the amount of pumping. The calculated groundwater pumping is a function of the available water from the surface (e.g., rainfall, surface water deliveries) and the demand of the surface land use (e.g., crop type). Table 6-1, shows annual groundwater pumping simulated by the C2VSimFG groundwater model across the entire Central Valley, from Red Bluff through the Tule region, including the Sacramento and San Joaquin valleys. The C2VSimFG model does not simulate limitations to groundwater pumping that may be imposed as part of a local GSP. Therefore, the simulated groundwater pumping values may overestimate the amount of groundwater pumping in certain areas. Groundwater basins denoted to be in overdraft conditions will likely have more limitations on groundwater pumping per SGMA.

Table 6-1. Simulated Groundwater Pumping in the Central Valley

Year	WY Type (Sacramento Valley, San Joaquin Valley)	NAA (TAF)	Alt1 (TAF)	Alt 2v1 (TAF)	Alt2v1 wTUC P (TAF)	Alt 2v2 (TAF)	Alt 2v3 (TAF)	Alt 3 (TAF)	Alt 4 (TAF)
1	W, W	11,480	11,398	11,476	11,476	11,484	11,491	12,089	11,471
2	W, W	11,974	11,742	11,929	11,929	11,998	12,010	12,742	11,795
3	C, C	15,993	15,914	16,052	16,052	16,051	16,049	16,392	15,971
4	C, C	18,361	18,242	18,365	18,459	18,371	18,378	19,281	18,406
5	AN, W	12,115	12,128	12,114	12,110	12,192	12,208	12,832	12,095
6	BN, AN	11,948	11,707	11,969	11,945	11,996	12,050	12,478	11,757
7	AN, W	11,024	10,972	11,017	11,011	11,101	11,121	11,588	10,963
8	D, D	13,572	13,266	13,587	13,587	13,650	13,686	14,395	13,554
9	W, W	10,224	10,141	10,232	10,233	10,238	10,245	10,931	10,229
10	W, W	9,317	9,316	9,315	9,317	9,312	9,313	9,810	9,316
11	W, AN	12,217	12,185	12,200	12,201	12,208	12,209	12,838	12,190
12	D, D	13,560	13,446	13,595	13,596	13,645	13,657	14,231	13,556
13	W, W	11,172	11,146	11,197	11,198	11,193	11,194	11,864	11,163
14	D, D	14,141	13,979	14,207	14,206	14,240	14,262	14,684	14,114
15	C, C	15,521	15,323	15,721	15,723	15,630	15,735	16,186	15,702
16	D, C	15,738	15,582	15,777	15,776	15,813	15,801	16,252	15,766
17	C, C	16,066	15,846	16,021	16,069	15,930	16,014	16,278	16,037
18	C, C	16,285	16,182	16,361	16,384	16,342	16,381	16,516	16,340
19	C, C	16,907	16,791	16,923	16,922	16,813	16,865	16,981	16,875
20	AN, W	11,852	11,612	11,681	11,670	11,775	11,774	12,553	11,649
21	C, C	14,650	14,403	14,864	14,847	14,807	14,876	15,351	14,625
22	W, W	10,618	10,574	10,669	10,665	10,660	10,672	11,450	10,608
23	W, W	11,582	11,550	11,581	11,580	11,581	11,584	12,407	11,562
24	W, W	11,688	11,594	11,638	11,638	11,639	11,638	12,384	11,636
25	W, W	9,077	9,085	9,080	9,079	9,085	9,085	9,737	9,084
26	W, AN	11,117	11,077	11,109	11,109	11,112	11,118	11,821	11,094
27	AN, AN	12,334	12,036	12,300	12,299	12,418	12,432	13,116	12,119
28	D, D	14,164	13,856	14,211	14,209	14,260	14,286	14,702	14,102
29	D, D	14,818	14,658	14,844	14,843	14,894	14,907	15,603	14,824
30	AN, BN	13,112	12,950	13,127	13,129	13,213	13,215	13,936	13,152

Year	WY Type (Sacramento Valley, San Joaquin Valley)	NAA (TAF)	Alt1 (TAF)	Alt 2v1 (TAF)	Alt2v1 wTUCP (TAF)	Alt 2v2 (TAF)	Alt 2v3 (TAF)	Alt 3 (TAF)	Alt 4 (TAF)
31	BN, D	14,433	14,090	14,439	14,449	14,529	14,556	15,142	14,422
32	AN, W	10,589	10,447	10,566	10,569	10,638	10,659	11,352	10,555
33	W, W	10,369	10,353	10,360	10,359	10,367	10,374	11,029	10,355
34	D, C	15,096	14,912	15,090	15,089	15,147	15,161	15,643	15,107
35	C, C	15,291	15,148	15,402	15,403	15,442	15,451	16,044	15,398
36	D, BN	15,777	15,638	15,807	15,802	15,858	15,867	16,169	15,818
37	BN, AN	12,847	12,748	12,873	12,874	12,927	12,936	13,366	12,817
38	W, W	10,067	10,036	10,068	10,068	10,062	10,067	10,714	10,051
39	BN, D	13,779	13,666	13,696	13,696	13,745	13,756	14,445	13,710
40	D, C	16,652	16,552	16,772	16,774	16,795	16,849	17,269	16,777
41	C, C	19,152	19,052	19,236	19,272	19,231	19,252	19,881	19,206
42	C, C	18,860	18,811	18,850	18,857	18,817	18,831	19,340	18,928
Average		**13,465**	**13,337**	**13,484**	**13,487**	**13,505**	**13,524**	**14,091**	**13,450**
Maximum		**19,152**	**19,052**	**19,236**	**19,272**	**19,231**	**19,252**	**19,881**	**19,206**
Minimum		**9,077**	**9,085**	**9,080**	**9,079**	**9,085**	**9,085**	**9,737**	**9,084**

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

Table 6-2, shows the change in annual average groundwater pumping as well as the range of changes to single year pumping.

Table 6-2. Simulated Change in Groundwater Pumping in the Central Valley for Each Alternative Compared to the No Action Alternative

Alternative	Average Annual Change in Groundwater Pumping	Maximum Single Year Change in Groundwater Pumping	Minimum Single Year Change in Groundwater Pumping
ALTERNATIVE 1			
TAF	-128	13	-343
% Difference	-0.9%	0.1%	-2.4%
ALTERNATIVE 2 WITH TUCP WITHOUT VA			
TAF	22	202	-182
% Difference	0.1%	1.3%	-1.5%

Alternative	Average Annual Change in Groundwater Pumping	Maximum Single Year Change in Groundwater Pumping	Minimum Single Year Change in Groundwater Pumping
ALTERNATIVE 2 WITHOUT TUCP WITHOUT VA			
TAF	19	214	-171
% Difference	0.1%	1.5%	-1.4%
ALTERNATIVE 2 WITHOUT TUCP DELTA VA			
TAF	40	156	-136
% Difference	0.3%	1.1%	-0.8%
ALTERNATIVE 2 WITHOUT TUCP SYSTEMWIDE VA			
TAF	59	226	-78
% Difference	0.4%	1.5%	-0.7%
ALTERNATIVE 3			
TAF	626	920	74
% Difference	4.9%	7.8%	0.4%
ALTERNATIVE 4			
TAF	-15	181	-215
% Difference	-0.2%	1.2%	-1.7%

TAF = thousand acre-feet

Positive numbers are an increase in pumping, negative numbers decreases in pumping

6.3.1.3 Central Coast

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. *Chapter 6, Water Supply*, provides an analysis of potential changes in surface water supply delivered by each of the alternatives. A conservative estimate would be that any decrease in surface water supply delivered to the Southern California Region would results in an equal increase in groundwater pumping and assuming that existing GWB hydrogeology can support the increase. All groundwater pumping would need to be conducted in accordance with existing regulatory setting such as an adjudication or GSP.

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

6.3.1.4 Southern California

Similar to the Central Coast Region, the C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Changes in surface water supply delivered to this region could result in changes in the amount of groundwater pumped. Chapter 6 provides an analysis of potential changes in surface water supply delivered. A conservative estimate would be that any decrease in surface water supply delivered to the Southern California Region would results in an equal increase in groundwater pumping and assuming that existing GWB hydrogeology can support the increase. Decreases in surface water supply delivered to this region may result in a decrease in groundwater pumping. All groundwater pumping would need to be conducted in accordance with existing regulatory setting such as an adjudication or GSP.

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

6.3.2 Potential Changes in Groundwater-Surface Water Interaction Flow

6.3.2.1 Trinity River

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

6.3.2.2 Central Valley

Table 6-3 shows annual groundwater-surface water interaction flow simulated by the C2VSimFG groundwater model across the entire Central Valley, from Red Bluff through the Tule region, including the Sacramento and San Joaquin valleys.

Table 6-3. Simulated Groundwater-Surface Water Interaction Flow in the Central Valley

Year	WY Type (Sacramento Valley, San Joaquin Valley)	NAA (TAF)	Alt 1 (TAF)	Alt 2v1 (TAF)	Alt2v1 wTUCP (TAF)	Alt 2v2 (TAF)	Alt 2v3 (TAF)	Alt 3 (TAF)	Alt 4 (TAF)
1	W, W	152	34	157	156	171	206	420	119
2	W, W	-73	-155	-78	-79	-61	-30	195	-81
3	C, C	29	-30	27	25	47	78	401	12
4	C, C	822	708	864	855	886	905	1,453	820
5	AN, W	3,033	2,937	3,044	3,098	3,068	3,090	3,570	3,014
6	BN, AN	731	652	753	757	754	810	1,200	764
7	AN, W	1,069	947	1,077	1,076	1,114	1,160	1,373	1,006
8	D, D	158	36	158	158	187	237	593	116
9	W, W	539	441	561	562	579	625	922	521
10	W, W	-588	-699	-583	-582	-558	-539	-39	-600
11	W, AN	-1,716	-1,842	-1,732	-1,731	-1,711	-1,695	-1,388	-1,754
12	D, D	-1,057	-1,178	-1,050	-1,049	-1,013	-985	-651	-1,078
13	W, W	-497	-598	-478	-478	-478	-451	-76	-506
14	D, D	-672	-776	-662	-662	-642	-612	-186	-726
15	C, C	-120	-228	-123	-123	-120	-58	402	-150
16	D, C	668	558	721	721	739	776	1,226	672
17	C, C	533	421	544	538	536	592	1,019	518
18	C, C	1,342	1,246	1,402	1,397	1,403	1,440	1,817	1,337
19	C, C	1,564	1,510	1,691	1,695	1,717	1,763	2,083	1,616
20	AN, W	1,932	1,817	1,957	1,946	1,947	1,973	2,176	1,899
21	C, C	996	917	998	1,002	1,019	1,065	1,392	979
22	W, W	2,140	2,000	2,186	2,188	2,184	2,220	2,548	2,107
23	W, W	840	685	860	859	860	890	1,250	806
24	W, W	572	442	580	579	586	610	1,063	531
25	W, W	107	-15	115	115	123	141	648	88
26	W, AN	-1,251	-1,391	-1,263	-1,263	-1,260	-1,242	-914	-1,302
27	AN, AN	-625	-740	-605	-606	-607	-575	-249	-628
28	D, D	-558	-676	-544	-546	-530	-485	-53	-595
29	D, D	-63	-191	-46	-47	-27	41	370	-65

Year	WY Type (Sacramento Valley, San Joaquin Valley)	NAA (TAF)	Alt 1 (TAF)	Alt 2v1 (TAF)	Alt2v1 wTUCP (TAF)	Alt 2v2 (TAF)	Alt 2v3 (TAF)	Alt 3 (TAF)	Alt 4 (TAF)
30	AN, BN	281	140	280	280	269	318	672	218
31	BN, D	94	-39	94	94	106	172	483	55
32	AN, W	297	172	309	310	327	381	774	295
33	W, W	141	-46	140	139	170	212	701	95
34	D, C	-313	-447	-303	-303	-289	-256	95	-323
35	C, C	250	144	240	241	255	316	822	215
36	D, BN	655	556	684	684	716	758	1,159	655
37	BN, AN	1,135	1,031	1,160	1,159	1,163	1,194	1,457	1,135
38	W, W	872	677	874	874	910	950	1,467	830
39	BN, D	-96	-254	-100	-100	-76	-44	328	-129
40	D, C	383	279	397	397	437	478	833	371
41	C, C	937	836	998	981	989	1,025	1,594	933
42	C, C	1,468	1,375	1,542	1,563	1,547	1,571	2,277	1,524
Average		**384**	**268**	**401**	**402**	**415**	**453**	**839**	**365**
Maximum		**3,033**	**2,937**	**3,044**	**3,098**	**3,068**	**3,090**	**3,570**	**3,014**
Minimum		**-1,716**	**-1,842**	**-1,732**	**-1,731**	**-1,711**	**-1,695**	**-1,388**	**-1,754**

TAF=thousand acre-feet; WY=water year

Water Year types: W=wet, AN=above normal, BN=below normal, D=dry, C=critical

Table 6-4 shows the change in annual average groundwater-surface water interaction flow as well as the range of changes to single year flow.

Table 6-4. Simulated Change in Groundwater-Surface Water Interaction Flow in the Central Valley for Each Alternative Compared to the No Action Alternative

Alternative	Average Annual Change in Groundwater-Surface Water Interaction Flow	Maximum Single Year Change in Groundwater-Surface Water Interaction Flow	Minimum Single Year Change in Groundwater-Surface Water Interaction Flow
ALTERNATIVE 1			
TAF	-116	-54	-194
% Difference	-44.8%	-3.2%	-206.1%
ALTERNATIVE 2 WITH TUCP WITHOUT VA			
TAF	18	130	-15
% Difference	2.0%	25.3%	-11.6%
ALTERNATIVE 2 WITHOUT TUCP WITHOUT VA			
TAF	17	126	-16
% Difference	2.3%	26.4%	-7.2%
ALTERNATIVE 2 WITHOUT TUCP DELTA VA			
TAF	32	153	-12
% Difference	9.1%	65.9%	-4.2%
ALTERNATIVE 2 WITHOUT TUCP SYSTEMWIDE VA			
TAF	69	199	9
% Difference	25.8%	170.8%	0.7%
ALTERNATIVE 3			
TAF	455	809	245
% Difference	173.2%	1301.7%	12.7%
ALTERNATIVE 4			
TAF	-19	56	-63
% Difference	-8.7%	4.6%	-56.7%

TAF = thousand acre-feet

Positive numbers are an increase in flow from surface water to groundwater, negative numbers are a decrease in the flow from surface water to groundwater.

6.3.2.3 Central Coast

The C2VSimFG groundwater model does not include a simulation of groundwater conditions in the Central Coast Region. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

6.3.2.4 Southern California

The C2VSimFG groundwater model does not include simulation of groundwater conditions in the Southern California Region. Increases in groundwater pumping have the potential to increase the amount of water that discharges from streams to groundwater.

6.3.3 Potential Changes in Groundwater Elevation

6.3.3.1 Trinity River

Given that there is likely to be little change to the volume of groundwater either through pumping or groundwater-surface water interaction flow, there will be little change to groundwater levels in the area are also not expected to change.

6.3.3.2 Central Valley

Increases in groundwater pumping are likely to result in a decrease in the elevation of groundwater. The distribution of changes in groundwater level will vary across the Central Valley as well as in time. Table 6-5 shows the average, maximum, and minimum changes in simulated groundwater levels for each of the alternatives compared to the No Action Alternative for the five water year types.

Table 6-5. Simulated Change in Groundwater Table Elevation (feet) in the Central Valley for Each Alternative Compared to the No Action Alternative for Each Water Year Type

Year Type	Wet	Above Normal	Below Normal	Dry	Critical
ALTERNATIVE 1					
Average	1.2	1.2	1.0	1.1	1.3
Maximum	32.6	31.0	29.9	30.7	32.5
Minimum	-0.6	-0.6	-1.4	-0.9	-1.2
ALTERNATIVE 2 WITH TUCP WITHOUT VA					
Average	-0.1	-0.1	-0.2	-0.2	-0.2
Maximum	2.9	3.0	2.2	2.3	1.8
Minimum	-9.6	-9.1	-9.4	-10.0	-12.7
ALTERNATIVE 2 WITHOUT TUCP WITHOUT VA					
Average	-0.2	-0.2	-0.2	-0.2	-0.2
Maximum	2.7	2.7	1.2	1.9	2.0
Minimum	-11.9	-10.9	-12.4	-12.1	-13.8

Year Type	Wet	Above Normal	Below Normal	Dry	Critical
ALTERNATIVE 2 WITHOUT TUCP DELTA VA					
Average	-0.6	-0.6	-0.6	-0.6	-0.6
Maximum	4.0	3.9	1.6	1.5	2.6
Minimum	-18.6	-16.8	-15.8	-16.8	-17.5
ALTERNATIVE 2 WITHOUT TUCP SYSTEMWIDE VA					
Average	-0.7	-0.7	-0.7	-0.7	-0.8
Maximum	2.3	2.6	1.0	0.9	1.4
Minimum	-18.1	-16.1	-17.7	-17.4	-19.5
ALTERNATIVE 3					
Average	-5.5	-5.1	-4.5	-5.0	-5.6
Maximum	0.5	0.7	0.5	0.7	2.4
Minimum	-158.6	-145.9	-125.0	-143.7	-155.2
ALTERNATIVE 4					
Average	0.2	0.2	0.2	0.2	0.2
Maximum	6.5	6.6	5.0	6.2	6.0
Minimum	-2.1	-2.2	-3.6	-2.5	-4.3

6.3.3.3 Central Coast

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Increase in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels.

Groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

6.3.3.4 Southern California

Increases in groundwater pumping in this region have the potential to reduce groundwater levels in the GWB and GWSB in the area. The decreases in surface water supply delivered are not expected to result in large increases in groundwater pumping, therefore, large decreases in groundwater levels are not expected. Increase in surface water supply delivery to the region may result in a reduction in groundwater pumping and, therefore, an increase in groundwater levels.

Groundwater pumping amounts stipulated in adjudications and GSPs may be supported by recharge from surface water supplies as well as recharge from recycled water. Surface deliveries from the SWP are important support both sources of recharge, because for some basins only

SWP supplies satisfy salinity standards. Without the ongoing support of groundwater recharge, groundwater levels may decrease.

6.3.4 Potential Changes in Land Subsidence

Additional information related to subsidence is available in Chapter 20, *Geology and Soils*, and Appendix W, *Geology and Soils Technical Appendix*.

6.3.4.1 Trinity River

The area along the Trinity River is not known to be susceptible to subsidence and groundwater pumping is not expected to increase in this region, suggesting that subsidence will not be a concern in this area.

6.3.4.2 Central Valley

On average, groundwater pumping is expected to increase (0.1% to 4.9%) for all alternatives compared to the No Action Alternative except for Alternatives 1 and 4. Annual groundwater pumping is expected to vary from year-to-year and include both increases and decreases. Periods of sustained increases in groundwater pumping are more likely to result in land subsidence in areas that are susceptible to subsidence.

Average groundwater levels are simulated to decrease up to approximately 13 feet for Alternative 2 With TUCP Without VA and up to approximately 14 feet for Alternative 2 Without TUCP Without VA in some water year types compared to the No Action Alternative. Groundwater levels may decrease closer to 19 feet for Alternative 2 Without TUCP Delta VA and 20 feet for Alternative 2 Without TUCP Systemwide VA compared to the No Action Alternative. Average groundwater levels are simulated to decrease up to approximately 159 feet for Alternative 3 in some water year types compared to the No Action Alternative. Average groundwater levels are generally expected to decrease up to 5 feet in certain water year types under Alternative 4 compared to the No Action Alterative. The largest decreases in groundwater levels are simulated to occur along the western portion of the Central Valley in the Sacramento Valley and in the San Joaquin Valley. Portions of these areas are known to have historic subsidence and further reductions in groundwater level may cause additional subsidence. Alternatives with larger decreases in groundwater levels have a higher likelihood of generating additional subsidence. The location and amount of subsidence is highly dependent on the local soil conditions and historical groundwater levels in the area.

6.3.4.3 Central Coast

The Central Coast region is not known to be susceptible to subsidence. Groundwater pumping is not expected to increase in this region suggesting that subsidence will not be a concern in this area.

6.3.4.4 Southern California

The Southern California region is not known to be susceptible to subsidence. Groundwater pumping is not expected to increase in this region suggesting that subsidence will not be a concern in this area.

6.3.5 Potential Changes in Groundwater Quality

6.3.5.1 Trinity River

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

6.3.5.2 Central Valley

Groundwater quality in the Central Valley has the potential to be affected if groundwater flow patterns and elevations change due to changes with implementation of the alternatives on groundwater pumping. Changes in groundwater pumping quantities and locations, and subsequent changes in groundwater elevation may result in groundwater moving faster or slower, in an altered flow direction, or to a different well. Increases or decreases in groundwater levels may also saturate or strand constituents in the soil matrix as the water table moves, thus changing the concentration of constituents in the groundwater. These changes in groundwater quality may result in a change in constituent concentrations depending on the local conditions and the water quality constituents present. The uncertainty in the distribution of water quality constituents does not allow for an assessment of the level of change, but groundwater quality may decrease due to changes from implementation of the alternatives.

6.3.5.3 Central Coast

Similar to the Central Valley, groundwater quality in the Central Coast Region has the potential to be affected if groundwater flow patterns and elevations change due to changes with implementation of the alternatives on groundwater pumping. The uncertainty in the distribution of water quality constituents does not allow for an assessment of the level of change, but groundwater quality may decrease due to changes from implementation of the alternatives.

6.3.5.4 Southern California

Similar to the Central Valley, groundwater quality in the Southern California Region has the potential to be affected if groundwater flow patterns and elevations change due to changes with implementation of the alternatives on groundwater pumping. The uncertainty in the distribution of water quality constituents does not allow for an assessment of the level of change, but groundwater quality may decrease due to changes from implementation of the alternatives.

6.4 Mitigation Measures

No avoidance and minimization measures or additional mitigation measures have been identified for groundwater.

6.5 Cumulative Impacts

The No Action Alternative would continue with the current operation of the CVP and is not expected to result in potential changes to groundwater pumping, groundwater-surface water interaction, groundwater elevation, land subsidence, and groundwater quality. The action alternatives will result in changes to groundwater pumping, groundwater-surface water interaction, groundwater elevation, land subsidence, and groundwater quality. The magnitude of the changes is dependent on alternative and water year type. Therefore, the No Action Alternative is not expected to contribute to cumulative changes to groundwater while the action alternatives may minimally contribute to cumulative changes to groundwater as described in Appendix I, *Groundwater* and Appendix Y, *Cumulative Impacts Technical Appendix*.