Long-Term Operation – Draft Environmental Impact Statement

Appendix W – Geology and Soils Technical Appendix

July 2024

Appendix W Geology and Soils Technical Appendix

W.1 Background Information

This appendix describes the affected environment for the study area regarding the geological setting, regional seismic and soils characteristics, and subsidence potential that could be potentially affected by the implementation of the alternatives considered in this environmental impact statement (EIS). Changes in geology and soils characteristics caused by changes in Central Valley Project (CVP) and State Water Project (SWP) operations may occur in the Trinity River region; Central Valley, including affected subwatersheds in the lower reaches of the Sacramento River, Clear Creek, American River, San Joaquin River, and Stanislaus River; Bay-Delta region; and CVP and SWP service areas. Geomorphic provinces in California are shown on Figure W-1.

W.1.1 Trinity River

The Trinity River region includes the area in Trinity County along the Trinity River from Trinity Reservoir to the confluence with the Klamath River, and the areas in Humboldt and Del Norte Counties along the Klamath River from the confluence with the Trinity River.

W.1.1.1 Geologic Setting

The Trinity River region is located within the southwest area of the Klamath Mountains Geomorphic Province and the northwest area of the Coast Ranges Geomorphic Province, as defined by the U.S. Geological Survey (USGS) geomorphic provinces (California Geological Survey 2002). The Klamath Mountains Geomorphic Province covers approximately 12,000 square miles of northwestern California between the Coast Range in the west and the Cascade Range in the east and is considered to be a northern extension of the Sierra Nevada (California Geological Survey 2002; Bureau of Reclamation 1997).

Volcanic mud flows and alluvial deposits are present downstream of Folsom Reservoir in the southwest corner of two major formations: Mehrten and Laguna. The Mehrten Formation contains volcanic conglomerate, sandstone, and siltstone, all derived from andesitic sources, and portions are gravels deposited by ancestral streams. The Laguna Formation, deposited predominately as debris flow on the Mehrten Formation, is a sequence of gravel, sand, and silt derived from granitic sources (Bureau of Reclamation et al. 2005b).

The area along the American River downstream of Folsom Reservoir and Nimbus Dam is located in the Great Valley Geomorphic Province. The area includes several geomorphic land types including dissected uplands and low foothills, low alluvial fans and plains, and river floodplains and channels. The dissected uplands consist of consolidated and unconsolidated continental Tertiary and Quaternary deposits that have been slightly folded and faulted (Bureau of Reclamation 2005b).

The alluvial fans and plains consist of unconsolidated continental deposits that extend from the edges of the valleys toward the valley floor (Bureau of Reclamation 2005b). The alluvial plains in the American River watershed include older Quaternary deposits (Sacramento County 2010). River flood plains and channel deposits lay along the American River as well as along smaller streams that flow into the Sacramento River south of the American River. Some floodplains are well defined, where rivers are incised into their alluvial fans. These deposits tend to be coarse and sandy in the channels and finer and silty in the floodplains (Bureau of Reclamation 2005b; Sacramento County 2010).

Stanislaus River and San Joaquin River

Stanislaus River

The Stanislaus River watershed originates in the Sierra Nevada Geomorphic Province, including the area with New Melones Reservoir, and extends into the Great Valley Geomorphic Province. New Melones Reservoir is oriented along a northwest trend that is produced by the Foothill Metamorphic Belt in the Sierra Nevada Geomorphic Province (Bureau of Reclamation 2010). The area is underlain by Cenozoic sedimentary rocks, which dip toward the southwest and overlies the Cretaceous sedimentary rocks of the Great Valley Sequence and older metamorphic basement rocks along the edges of the Sierra Nevada. Tertiary sedimentary formations were deposited along the Stanislaus River from an area east of Knights Ferry to Oakdale (California Geological Survey 2010). The oldest Tertiary geologic unit, the Eocene Ione Formation, primarily consists of quartz, sandstone, and interbedded kaolinitic clays with a maximum thickness of about 200 feet near Knights Ferry. The Oligocene-Miocene Valley Springs Formation of rhyolitic ash, sandy clay, and gravel deposits overlay the Ione Formation. Andesitic flows, lahars, and volcanic sediments of the Mehrten Formation were deposited by volcanism, especially from Table Mountain (California Geological Survey 2010; Bureau of Reclamation 2010). Three major alluvial fan deposits occurred along the Stanislaus River after deposition of the Mehrten Formation, including the Turlock Reservoir Formation (between Orange Blossom Road and Oakdale) composed of fine sand and silt with some clay, sand, and gravel; Riverbank Formation (between Oakdale and Riverbank) composed of silt and clay; and Modesto Formation (between Riverbank and the confluence with the San Joaquin River) composed of sand, silt, clay, and gravel.

Foothills soils, located on well-drained, hilly-to-mountainous terrain along the east side of the Central Valley, form through in-place weathering of the underlying rock. Soils in the northern Sacramento Valley near Shasta Reservoir are different from soils along other foothills in the Sacramento and San Joaquin Valleys. The soils near Shasta Reservoir are related to the geologic formations of the Klamath Mountains and Cascade Ranges Geomorphic Provinces. These soils are formed from weathered metavolcanic and metasedimentary rocks, from intrusions of granitic rocks, serpentine, and basalt and localized dormant, deep-seated landslide features. Other than the landslide features that may have high clay content with high water-holding capacity, these soils are generally shallow with numerous areas of gravels, cobbles, and stones; therefore, they do not have high water-holding capacity or support topsoil productivity for vegetation (Bureau of Reclamation 2014). Soils derived from in-place weathering of granitic rock, referred to as decomposed granite, are coarse-grained, quartz-rich, and erodible.

Upland soils along other foothills in the Sacramento and San Joaquin Valleys are formed from the Sierra Nevada and Coast Ranges Geomorphic Provinces. Along the western boundary of the Central Valley, the soils primarily are formed from sedimentary rocks. Along the eastern boundary of the Central Valley, the soils primarily are formed from igneous and metamorphic rock. The soils include serpentine soils (which include magnesium, nickel, cobalt, chromium, iron, and asbestos); sedimentary sandstones; shales; conglomerates; and sandy loam, loam, and clay loam soils above bedrock (Bureau of Reclamation 1997, 2014; Bureau of Reclamation and California Department of Water Resources 2011; California Department of Water Resources 2007). Erosion occurs in the upland soils around reservoirs and rivers especially downgradient of urban development where paving increases the peak flow, volume, and velocity of precipitation runoff (Geotechnical Consultants 2003).

Along the western boundary of the Sacramento Valley and the southeastern boundary of the San Joaquin Valley, the terrace lands include brownish loam, silt loam, and/or clayey loam soils. The soils are generally loamy along the Sacramento Valley terraces and more clayey along the San Joaquin Valley terraces. Along the eastern boundaries of Sacramento and San Joaquin Valleys, the terraces are primarily red silica-iron cemented hardpan and clays, sometimes with calcium carbonate (also known as lime) (California Department of Water Resources 2007; Bureau of Reclamation 1997, 2005b, 2013).

Surface soils of the Central Valley include alluvial and Aeolian soils. The alluvial soils include calcic brown and noncalcic brown alluvial soils on deep alluvial fans and floodplains. The calcic brown soil is primarily made of calcium carbonate and alkaline (also known as “calcareous” soils). The noncalcic brown soils do not contain calcium carbonate and are either slightly acidic or neutral in chemical properties. In the western San Joaquin Valley, light-colored calcareous soils occur with less organic matter than the brown soils (Bureau of Reclamation 1997).

Soils within the Yolo Bypass area, located in the southwestern portion of the Sacramento Valley, range from clays to silty clay loams and alluvial soils (CALFED Bay-Delta Program 2001; California Department of Fish and Game 2008). The higher clay content soils occur in the western portion of the area north of I-80 and in the eastern portion of the area south of I-80. The silty clay loams and alluvial soils occur in the western portion of the Yolo Bypass area south of I-80, including soils within the Yolo Bypass Wildlife Area.

Basin soils occur in the San Joaquin Valley and portions of the Delta. These soils include organic soils, imperfectly drained soils, and saline alkali soils. The organic soils are typically dark, acidic, high in organic matter, and generally include peat. The organic soils occur in the Delta, as discussed below, and along the lower San Joaquin River adjacent to the Delta. The poorly drained soils contain dark clays and occur in areas with high groundwater in the San Joaquin Valley trough and as lakebed deposits (Bureau of Reclamation and California Department of Water Resources 2011). One of the most substantial stratigraphic features of the San Joaquin Valley and a major aquitard is the Corcoran Clay, located in the western and Central Valley (Galloway and Riley 1999). The Corcoran Clay generally extends from Mendota Pool area through the center of the valley to the Tehachapi Mountains. The depth to the Corcoran Clay varies from 160 feet under the Tulare Lake lakebed to less than a foot near the western edge of the Central Valley. The Corcoran Clay is composed of numerous aquitards (a geologic formation with slow or no water transmission that acts as a barrier to groundwater movement) and coarser interbeds.

Selenium salts and other salts occur naturally in the western and central San Joaquin Valley soils that are derived from marine sedimentary rocks of the Coast Ranges. Salts are leached from the soils by applied pre-irrigation and irrigation water and collected by a series of drains. The drains also reduce high groundwater elevations in areas with shallow clay soils. The Bureau of Reclamation (Reclamation) and other agencies are implementing programs to reduce salinity issues in the San Joaquin Valley that will convey and dispose of drainage water in a manner that would protect the surface water and groundwater resources (Bureau of Reclamation and California Department of Water Resources 2011). As described in Appendix R, *Land Use and Agricultural Resources Technical Appendix*, areas in the western and southern San Joaquin Valley are affected by shallow, saline groundwater that accumulates because of irrigation, and the shallow groundwater is underlain by soils with poor drainage.

Soils in the eastern San Joaquin Valley come from the Sierra Nevada and contain low levels of salt and selenium. Most soils in the western and southern San Joaquin Valley are formed from Coast Range marine sediments and contain higher concentrations of salts as well as selenium and molybdenum. Soluble selenium moves from soils into drainage water and groundwater, especially during agricultural operations to leach salts from the soils. As described in Appendix D, *Draft Alternatives*, Reclamation and other agencies are implementing programs to reduce the discharge of selenium from the San Joaquin Valley into receiving waters (Bureau of Reclamation 2005c, 2009; Bureau of Reclamation and California Department of Water Resources 2011). Additional information related to concerns with salinity and selenium in the San Joaquin Valley is presented in Appendix G, *Water Quality Technical Appendix*, and Appendix R.

Soil wind erosion is related to soil erodibility, wind speeds, soil moisture, surface roughness, and vegetative cover. Aeolian soils are more susceptible to wind erosion than alluvial soils. Non-irrigated soils that have been disturbed by cultivation or other activities throughout the Central Valley are more susceptible to wind erosion and subsequent blowing dust than soils with more soil moisture. Dust from eroding soils can create hazards due to soil composition (such as naturally occurring asbestos), which include allergic reactions to dust, adverse impacts to plants due to dust, and increased risk of Valley fever (Bureau of Reclamation 2005c).

Table W-1. Trinity Reservoir Storage and Trinity River Release Prediction for No Action Alternative and Alternatives 1 through 4

Parameter	Alternative	Dry Period Drawdown (TAF)[1,3]	Wet Period Drawdown (TAF)[2,4]	Difference between No Action Alternative and Alternative Dry Period Drawdown (TAF) and (% Change)		Difference between No Action Alternative and Alternative Wet Period Drawdown (TAF) and (% Change)	
Trinity Lake Storage	No Action Alternative	818	2188	—	0%	—	0%
	Alternative 1	827	2189	9	1%	1	0%
	Alternative 2 Without TUCP Without VA	802	2172	-16	-2%	-16	-1%
	Alternative 2 With TUCP Without VA	807	2172	-11	-1%	-16	-1%
	Alternative 2 Without TUCP With Delta VA	805	2172	-13	-2%	-16	-1%
	Alternative 2 Without TUCP All VA	800	2167	-18	-2%	-21	-1%
	Alternative 3	881	2172	63	8%	-16	-1%
	Alternative 4	786	2172	-32	-4%	-16	-1%
Trinity River Release	No Action Alternative	41.4	813	—	0%	—	0%
	Alternative 1	40.1	798	-1.3	-3%	-15	-2%
	Alternative 2 Without TUCP Without VA	37.8	818	-3.7	-9%	5	1%
	Alternative 2 With TUCP Without VA	37.8	817	-3.7	-9%	5	1%
	Alternative 2 Without TUCP With Delta VA	37.8	812	-3.7	-9%	-1	0%
	Alternative 2 Without TUCP All VA	37.8	806	-3.7	-9%	-7	-1%

Parameter	Alternative	Dry Period Drawdown (TAF)	Wet Period Drawdown (TAF)	Difference between No Action Alternative and Alternative Dry Period Drawdown (TAF) and (% Change)		Difference between No Action Alternative and Alternative Wet Period Drawdown (TAF) and (% Change)	
	4	1575	4225	134	9%	7	0%
Sacramento River Release	No Action Alternative	487	4554	—	0%	—	0%
	1	471	4605	-16	-3%	51	1%
	Alternative 2 Without TUCP Without VA	510	4695	23	5%	141	3%
	Alternative 2 With TUCP Without VA	500	4630	13	3%	76	2%
	Alternative 2 Without TUCP With Delta VA	496	4628	9	2%	74	2%
	Alternative 2 Without TUCP All VA	496	4714	9	2%	160	4%
	3	505	4687	18	4%	133	3%
	4	492	4560	5	1%	6	0%

Notes:
[1] Dry period releases for Shasta Lake Storage are based upon the 90% exceedance for the months of September to November only for the 1922 – 2021 CalSim 3 simulation period.
[2] Wet period releases for Shasta Lake Storage are based upon the 10% exceedance for the months of March to May only for the 1922 – 2021 CalSim 3 simulation period.
[3] Dry period releases for Sacramento River Release are based upon the 90% exceedance for the months of December to February only for the 1922 – 2021 CalSim 3 simulation period.
[4] Wet period releases for Sacramento River Release are based upon the 10% exceedance for the months of November to March only for the 1922 – 2021 CalSim 3 simulation period.

Parameter	Alternative	Dry Period Drawdown (TAF)	Wet Period Drawdown (TAF)	Difference between No Action Alternative and Alternative Dry Period Drawdown (TAF) and (% Change)		Difference between No Action Alternative and Alternative Wet Period Drawdown (TAF) and (% Change)	
	Alternative 3	139	2827	-36	-20%	0	0%
	Alternative 4	150	2789	-25	-14%	-38	-1%

Notes:
[1] Dry period releases for Folsom Lake Storage are based upon the 90% exceedance for the months of x to x only for the 1922 – 2021 CalSim 3 simulation period.
[2] Wet period releases for Folsom Lake Storage are based upon the 10% exceedance for the months of x to x only for the 1922 – 2021 CalSim 3 simulation period.
[3] Dry period releases for American River Release are based upon the 90% exceedance for the months of x to x only for the 1922 – 2021 CalSim 3 simulation period.
[4] Wet period releases for American River Release are based upon the 10% exceedance for the months of x to x only for the 1922 – 2021 CalSim 3 simulation period.

Under Alternative 1, Folsom Reservoir drawdowns for dry periods is 76 TAF (24% change) more than the No Action Alternative. Therefore, there is a greater likelihood for mass wasting and surface erosion to occur for this alternative during dry periods than what would occur under the No Action Alternative. Wet periods are equal to those in the No Action Alternative (0 TAF); therefore, there would be no changes in erosion or mass wasting.

In the American River, Alternative 1 would release up to 75 TAF (-43% change) less during dry periods and would likely not result in erosion in the American River as compared with the No Action Alternative. During wet periods, conditions are equal to those in the No Action Alternative (0 TAF) and, therefore, mass wasting and surface erosion would be comparable to the No Action Alternative.

The Yolo Bypass carries flood flows that spill from the Sacramento River at the Fremont Weir during large winter storm events, with the highest flows occurring typically December through February. Flows through the Yolo Bypass are expected to increase by 1.6% under Alternative 1 compared with the No Action Alternative, increasing from 28,132 cubic feet per section (cfs) to 28,592 cfs. This minor increase in winter flood flows through the Yolo Bypass is negligible given the low channel gradient, large cross-sectional area for flow, and low flow velocities at the margins of the bypass and is not expected to result in a change in erosion.

When compared with the No Action Alternative, Alternative 1 would decrease lands subject to fallowing in the Sacramento River region by 955 acres during average water years, which is 0.05% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be a decrease of 4,379 acres of fallowed land, which is a 0.22% decrease of the total irrigated lands subject to erosion. Therefore, erosion could decrease under Alternative 1 compared with the No Action Alternative.

San Joaquin Valley

Table W-4 and Table W-5 provide information for New Melones Reservoir and Millerton Reservoir storage and release information on the Stanislaus River and San Joaquin River used to evaluate changes for action alternatives compared with the No Action Alternative.

Table W-4. New Melones Reservoir Storage and Stanislaus River Release for No Action Alternative and Alternatives 1 through 4.

Parameter	Alternative	Dry Period Drawdown (TAF)	Wet Period Drawdown (TAF)	Difference between No Action Alternative and Alternative Dry Period Drawdown (TAF) and (% Change)		Difference between No Action Alternative and Alternative Wet Period Drawdown (TAF) and (% Change)	
New Melones Lake Storage	No Action Alternative	1009	2202	—	0%	—	0%
	Alternative 1	1055	2189	46	5%	-13	-1%
	Alternative 2 Without TUCP Without VA	1003	2226	-6	-1%	24	1%
	Alternative 2 With TUCP Without VA	1004	2226	-5	-1%	24	1%
	Alternative 2 Without TUCP With Delta VA	1003	2226	-6	-1%	24	1%
	Alternative 2 Without TUCP All VA	1002	2226	-7	-1%	24	1%
	Alternative 3	1020	2149	11	1%	-53	-2%
	Alternative 4	1004	2226	-5	-1%	24	1%
Stanislaus River Release	No Action Alternative	41	671	—	0%	—	0%
	Alternative 1	47	719	6	13%	48	7%
	Alternative 2 Without TUCP Without VA	44	693	3	6%	22	3%
	Alternative 2 With TUCP Without VA	44	693	3	6%	22	3%
	Alternative 2 Without TUCP With Delta VA	44	693	3	6%	22	3%
	Alternative 2 Without TUCP All VA	44	693	3	6%	22	3%
	Alternative 3	43	740	2	4%	69	10%
	Alternative 4	44	693	3	7%	22	3%

Table W-5. Millerton Reservoir Storage and San Joaquin River Release Prediction for No Action Alternative and Alternatives 1 through 4.

Parameter	Alternative	Dry Period Drawdown (TAF)	Wet Period Drawdown (TAF)	Difference between No Action Alternative and Alternative Dry Period Drawdown (TAF) and (% Change)		Difference between No Action Alternative and Alternative Wet Period Drawdown (TAF) and (% Change)	
Millerton Lake Storage	No Action Alternative	139	458	—	0%	—	0%
	Alternative 1	139	458	0	0%	0	0%
	Alternative 2 Without TUCP Without VA	139	458	0	0%	0	0%
	Alternative 2 With TUCP Without VA	139	458	0	0%	0	0%
	Alternative 2 Without TUCP With Delta VA	139	458	0	0%	0	0%
	Alternative 2 Without TUCP All VA	139	459	0	0%	1	0%
	Alternative 3	138	457	-1	-1%	-1	0%
	Alternative 4	139	458	0	0%	0	0%
San Joaquin River Releases	No Action Alternative	11.8	520	—	0%	—	0%
	Alternative 1	11.5	520	-0.3	-2%	0	0%
	Alternative 2 Without TUCP Without VA	11.8	520	0	0%	0	0%
	Alternative 2 With TUCP Without VA	11.8	520	0	0%	0	0%
	Alternative 2 Without TUCP With Delta VA	11.8	520	0	0%	0	0%
	Alternative 2 Without TUCP All VA	11.8	520	0	0%	0	0%
	Alternative 3	12.4	519	0.6	5%	-1	0%
	Alternative 4	11.8	520	0	0%	0	0%

Notes:

[1] Dry period releases for Millerton Lake Storage are based upon the 90% exceedance for the months of September to November only for the 1922 – 2021 CalSim 3 simulation period.

[2] Wet period releases for Millerton Lake Storage are based upon the 10% exceedance for the months of March to June only for the 1922 – 2021 CalSim 3 simulation period.

[3] Dry period releases for San Joaquin River Release are based upon the 90% exceedance for the months of June to September only for the 1922 – 2021 CalSim 3 simulation period.
[4] Wet period releases for San Joaquin River Release are based upon the 10% exceedance for the months of March to June only for the 1922 – 2021 CalSim 3 simulation period.

When compared with the No Action Alternative, Alternative 1 would result in a decrease in lands subject to fallowing in the San Joaquin River region by 91,372 acres during average water years, which is 2.88% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be a decrease of 87,164 acres of fallowed land, a 3.01% decrease of the total irrigated lands subject to erosion. This decrease in fallowed lands could reduce the potential for erosion compared with the No Action Alternative.

Bay-Delta Operations

No changes in flows are expected in the Bay-Delta region under Alternative 1 compared with the No Action Alternative; therefore, stream channel erosion would not be associated with Alternative 1 in this area. No changes in flows are expected in the Suisun Marsh or the San Francisco Bay under Alternative 1; therefore, there is no expected change to erosion rates.

With regards to changes in irrigated acreage, as described in Appendix R, this region was not modeled under SWAP, and flows on average would increase in this region under Alternative 1 compared with the No Action Alternative. Therefore, conversion of agricultural land or crop idling is not anticipated, and soil erosion caused by these factors would not change compared with the No Action Alternative.

Additional CVP and SWP Service Areas

There are no Reclamation storage reservoirs or affected stream reaches in the CVP and SWP service areas; therefore, erosion as a result of changes to flow is not a concern in these areas.

With regards to changes in irrigated acreage, as described in Appendix R, this region was not modeled under SWAP. Flows would increase in this region under Alternative 1 compared with the No Action Alternative. Therefore, no conversion of agricultural land or crop idling is anticipated, and soil erosion caused by these factors would not occur.

W.2.3.2 Potential Changes in Rate of Land Subsidence Due to Increased Use of Groundwater

Trinity River

As described in Appendix I, 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; therefore, subsidence is not a concern in this area.

Central Valley

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

Southern California Region

The Southern California region is not known to be highly susceptible to subsidence, as noted in Appendix I, Section I.2.3.4.4, *Southern California Region*. Groundwater pumping is not expected to increase in this region, suggesting that subsidence would not be a concern in this area.

W.2.4 Alternative 2

W.2.4.1 Potential Changes in Soil Erosion

Trinity River

During dry periods, for all phases of Alternative 2, the drawdown values of Trinity Reservoir Storage are negligible and negative (-11 TAF to -18 TAF, -1 to -2% change) compared with the No Action Alternative, as shown in Table W-1. Therefore, there would be no changes in shoreline exposure resultant in mass wasting and surface erosion. Similarly, during wet conditions, Alternative 2 phases have negligible values ranging from -16 TAF to -21 TAF (approximately -1% change), as shown in Table W-1, and therefore no mass wasting and surface erosion would result in comparison with the No Action Alternative.

Changes in flows during wet periods are expected in the Trinity River below Lewiston Dam under all phases of Alternative 2 ranging from 5 TAF to -7 TAF (approximately -1% to 1% change), as shown in Table W-1. All phases under wet periods are negligible. During dry periods, all phases of Alternative 2 in the Trinity River are negative (-4 TAF, -9% change), indicating less erosion and mass wasting than the No Action Alternative.

No agricultural lands in the Trinity River area are served by CVP and SWP water supplies. As a result, the Trinity River region was not included in the SWAP model used to evaluate effects of the project upon irrigated acreage. No conversion of agricultural land or crop idling is anticipated. Soil erosion due to changes in irrigated acreage is not affected by CVP or SWP activity.

Sacramento Valley

During dry periods in Shasta Reservoir, all phases of Alternative 2 have positive drawdown values ranging from 157 TAF (11% change) to 306 TAF (21% change), as shown in Table W-2. Positive drawdown values indicate the likelihood for mass wasting and surface erosion would be greater under Alternative 2 than those for the No Action Alternative. For wet periods, all phases of Alternative 2 have negligible percent changes (approximately 0% change), and therefore there are no changes in mass wasting and surface erosion expected under wet conditions.

The Sacramento River Release's drawdown is negligible during both dry and wet periods. The drawdown values for dry periods range between 9 TAF (2% change) to 23 TAF (5% change) and wet periods of 74 TAF (2% change) to 160 TAF (4% change), as shown in Table W-2. No change for mass wasting and surface erosion is expected to occur for this alternative compared with the No Action Alternative.

During dry periods, Folsom Reservoir drawdown for all phases except for Alternative 2 Without TUCP Without VA are negligible, 4 TAF (1% change) to 8 TAF (2% change), as shown in Table W-3. No changes in likelihood of mass wasting and surface erosion are expected. For wet periods, all phases of Alternative 2 are negligible and negative, -1 (approximately 0% change) to -5 TAF (-1% change), as shown in Table W-3. No change in the likelihood for mass wasting and surface erosion for Alternative 2 is expected relative to the No Action Alternative.

The American River Release during dry periods has negative drawdown values, ranging from -25 TAF to -55 TAF (-14% to -55% change), for all phases of Alternative 2, predicting a lower likelihood for mass wasting and surface erosion to occur for this alternative than what would occur for the No Action Alternative (Table W-3). During wet periods, all phases have negligible negative values ranging from 0 TAF (0% change) to -30 TAF (-1% change), as shown in Table W-3. No changes for mass wasting and surface erosion in the American River are expected during all phases of Alternative 2 relative to the No Action Alternative.

The Yolo Bypass carries flood flows that spill from the Sacramento River at the Fremont Weir during large winter storm events, typically December through February. Flows through the Yolo Bypass are expected to increase between 0.4% and 0.5% under both Alternative 2 Without TUCP Without VA and Alternative 2 With TUCP Without VA, increasing from 28,132 cfs under the No Action Alternative to 28,252 cfs and 28,264 cfs, respectively. However, these winter flows through the Yolo Bypass are expected to decrease between 0.7% and 1.4% under Alternative 2 Without TUCP With Delta VA and Alternative 2 Without TUCP All VA, decreasing from 28,132 cfs in the No Action Alternative to 27,939 cfs and 27,736 cfs, respectively. These minor increases and decreases in winter flood flows through the Yolo Bypass would result in negligible changes in riverine erosion given the low channel gradient, large cross-sectional area for flow, and low flow velocities at the margins of the bypass.

When compared with the No Action Alternative, Alternative 2 With TUCP Without VA would increase lands subject to fallowing in the Sacramento River region by 650 acres during average water years, which is 0.03% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 5,094 acres of fallowed land, a 0.25% increase of the total irrigated lands subject to erosion. Therefore, the potential for erosion due to fallowing would increase compared with the No Action Alternative.

When compared with the No Action Alternative, Alternative 2 Without TUCP Without VA would increase lands subject to fallowing in the Sacramento River region by 4,640 acres during average water years, which is 0.23% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 5,589 acres of fallowed land, a 0.27% increase of the total irrigated lands subject to erosion. Therefore, the potential for erosion would increase compared with the No Action Alternative.

When compared with the No Action Alternative, Alternative 2 Without TUCP Delta VA would increase lands subject to fallowing in the Sacramento River region during average water years by 5,076 acres, which is 0.25% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 4,320 acres of fallowed land, a 0.21% increase of the total irrigated lands subject to erosion.

Therefore, the potential for erosion associated with fallowing would increase compared with the No Action Alternative.

When compared with the No Action Alternative, Alternative 2 Without TUCP Systemwide VA would increase lands subject to fallowing in the Sacramento River region during average water years by 7,038 acres, which is 0.34% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 5,093 acres of fallowed land, a 0.25% increase of the total irrigated lands subject to erosion. Therefore, the potential for erosion would increase compared with the No Action Alternative.

San Joaquin Valley

During dry periods, all phases of Alternative 2 for the New Melones Reservoir have negligible negative drawdown values ranging between -5 TAF and -7 TAF (approximately -1% change), as shown in Table W-4. This negative drawdown indicates no changes to mass wasting and surface erosion associated with reservoir drawdown than predicted for the No Action Alternative for. For wet periods, all phases of Alternative 2 are negligible and positive, 24 TAF (1% change), as shown in Table W-4, denoting no changes for mass wasting and surface erosion when compared with the No Action Alternative. Releases to the Stanislaus River from the New Melones Reservoir under all phases for dry periods (3 TAF, 6% change) show an increased likelihood of mass wasting and surface erosion during high flow; however, wet periods (22 TAF, 3% change) have negligible, positive values denoting no changes for mass wasting and surface erosion for this alternative than what is predicted for the No Action Alternative.

Under Alternative 2, there is no changes in operations to the CVP with respect to storage of water in Millerton Reservoir or release of water to the San Joaquin River (Table W-5).

When compared with the No Action Alternative, Alternative 2 With TUCP Without VA would decrease lands subject to fallowing in the San Joaquin River region by 4,701 acres during average water years, which is 0.15% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 22,585 acres of fallowed land, a 0.25% increase of the total irrigated lands subject to erosion. This increase in irrigated lands would decrease the potential for erosion during average water years and increase the potential for erosion during critical and dry water year types.

When compared with the No Action Alternative, Alternative 2 Without TUCP Without VA would increase lands subject to fallowing in the San Joaquin River region by 14,994 acres during average water years, which is 0.23% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 26,171 acres of fallowed land, a 0.82% increase of the total irrigated lands subject to erosion. This would increase the potential for erosion.

When compared with the No Action Alternative, Alternative 2 Without TUCP Delta VA would increase lands subject to fallowing in the San Joaquin River region by 47,732 acres during average water years, which is 1.50% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 47,500 acres of fallowed land, a 1.50% increase of the total irrigated lands subject to erosion. This increase in fallowed land would increase the potential for erosion.

When compared with the No Action Alternative, Alternative 2 Without TUCP Systemwide VA would increase lands subject to fallowing in the San Joaquin River by 47,769 acres during average water years, which is 1.50% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 41,257 acres of fallowed land, a 1.43% increase of the total irrigated lands subject to erosion. This increase in fallowed land would increase the potential for erosion.

Bay-Delta Operations

There are no storage reservoirs associated with the Bay-Delta region so no changes in reservoir water levels would occur that could result in shoreline erosion. No changes in flows are expected in the Bay-Delta under Alternative 2 (all phases), compared with the No Action Alternative; therefore, changes to erosion rates associated with Alternative 2 would not occur in this area. No changes in flows are expected in the Suisun Marsh or the San Francisco Bay under Alternative 2; therefore, there is no expected change to erosion rates.

This region was not modeled under SWAP. Flows on average would decrease in this region under the phases of Alternative 2 compared with the No Action Alternative. Therefore, an increase in fallowing of agricultural land is anticipated. The potential for soil erosion would increase compared with the No Action Alternative.

Additional CVP and SWP Service Areas

There are no Reclamation reservoirs or affected stream reaches associated with the Central Coast or Southern California regions; therefore, erosion as a result in changes to flow is not a concern in this area.

This region was not modeled under SWAP. Flows would increase in this region under Alternative 2 compared with the No Action Alternative. Therefore, no conversion of agricultural land or crop idling is anticipated, and soil erosion caused by these factors would not occur.

W.2.4.2 Potential Changes in Land Subsidence Due to Increased Use in Groundwater

Trinity River

As described in Appendix I, 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; therefore, subsidence is not expected be a concern in this area.

Central Valley Region

In the Sacramento and San Joaquin Valleys, average groundwater levels are generally expected to remain the same or decrease the potential for additional subsidence exists. Average simulated groundwater levels decrease up to approximately 12 feet for Alternative 2 With TUCP Without VA and Alternative 2 Without TUCP Without VA in some water year types compared with the No Action Alternative. Groundwater levels may decrease by as much as 20 feet for Alternative 2 Without TUCP Delta VA and Alternative 2 Without TUCP Systemwide VA compared with the No Action Alternative. The largest decreases in simulated groundwater levels would 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 additional subsidence under all phases of Alternative 2 when compared with the No Action Alternative. The location and amount of subsidence is highly dependent on the local soil conditions and historical low groundwater levels throughout the Central Valley region.

Southern California Region

The Southern California region is not known to be susceptible to subsidence and, as was noted in Appendix I, Section I.2.4.4.4, *Southern California Region*, groundwater pumping is not expected to increase in this region, suggesting that subsidence would not be a concern in this area.

W.2.5 Alternative 3

W.2.5.1 Potential Changes in Soil Erosion

Trinity River

Alternative 3 during dry periods has the largest drawdown for Trinity Reservoir compared with the No Action Alternative with 63 TAF (8% change) (Table W-1); therefore, shoreline erosion would increase relative to the No Action Alternative. The potential for increased erosion would be negligible. During wet periods, the potential for shoreline erosion would be less than the No Action Alternative (-16 TAF) (-1% change) and would be negligible. During releases from Trinity Reservoir during dry periods, Alternative 3 would have an increase in releases with 2.4 TAF (6% change) that would likely result in an increase in erosion of the bed and banks of the Trinity River when compared with the No Action Alternative when it experiences high flow, as shown in Table W-1. During wet periods, Alternative 3 would result in -63 TAF (-8% change), which could lead to a decrease in erosion compared with the No Action Alternative. Potential impacts to the Trinity River under both dry and wet periods would be negligible.

No agricultural lands in the Trinity River area are served by CVP and SWP water supplies. As a result, the Trinity River region was not included in the SWAP model used to evaluate effects of the project upon irrigated acreage. No conversion of agricultural land or crop idling is anticipated. Soil erosion due to changes in irrigated acreage is not affected by CVP or SWP activity.

Sacramento Valley

Alternative 3 for Shasta Reservoir storage, during dry and wet periods, has positive drawdown values (461 TAF for dry and 34 TAF for wet periods, 32% change and 1 % change, respectively), as shown in Table W-2. Therefore, there is a greater likelihood for mass wasting and surface erosion compared with No Action Alternative. During release from Shasta Reservoir, the drawdown values are positive, 18 TAF (4% change) in dry years and 133 TAF (3% change) in wet years, denoting a negligible change in likelihood for mass wasting and surface erosion in the Sacramento River to occur in comparison to the No Action Alternative.

Storage for Folsom Reservoir during dry periods has a positive drawdown value (15 TAF, 5% change), denoting a negligible change in potential for mass wasting and surface erosion to occur than for the No Action Alternative, as shown in Table W-3. For wet periods, this value is negative (-2 TAF, approximately 0% change), indicating a negligible change for mass wasting and surface erosion to occur than what is predicted for the No Action Alternative. During release from Folsom Reservoir, the dry periods have a negative drawdown, -36 TAF (-20% change), showing a smaller likelihood for erosion in the American River to occur than for the No Action Alternative, as shown in Table W-3. Wet periods would show no change (0 TAF) compared with the No Action Alternative.

The Yolo Bypass carries flood flows that spill from the Sacramento River at the Fremont Weir during large winter storm events, typically December through February. Flows through the Yolo Bypass are expected to increase by 9.5% under Alternative 3, compared with the No Action Alternative, increasing from 28,132 cfs to 30,811 cfs. This minor increase in winter flood flows through the Yolo Bypass would result in negligible riverine erosion given the low channel gradient, large cross-sectional area for flow, and low flow velocities at the margins of the bypass.

When compared with the No Action Alternative, Alternative 3 would increase lands subject to fallowing in the Sacramento River region by 22,218 acres during average water years, which is 1.11% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 21,123 acres of fallowed land, a 1.03% increase of the total irrigated lands subject to erosion. This would increase the potential for erosion.

San Joaquin Valley

During dry periods, Alternative 3 would result in a positive drawdown, 11 TAF (1% change), and therefore the shoreline of New Melones Reservoir is not likely to experience mass wasting and surface erosion when compared with the No Action Alternative because the percent change is negligible, as shown in Table W-4. During wet periods, Alternative 3 has a negligible negative drawdown (-53 TAF, -2% change), and thus the shoreline of New Melones Reservoir is less likely to experience mass wasting and surface erosion when compared with the No Action Alternative. Releases from New Melones Reservoir to the Stanislaus River would result in positive drawdown values during dry periods (2 TAF, 4% change) and wet periods (69 TAF, 10% change), denoting that there is a greater likelihood for channelized erosion in the Stanislaus River during wet periods when compared with the No Action Alternative, as shown in Table W-4.

Under Alternative 3, there would be no changes to the operation of Millerton Reservoir, nor releases to the San Joaquin River relative to the No Action Alternative. Therefore, no impacts related to shoreline erosion surrounding Millerton Reservoir or flow erosion of the San Joaquin River beyond those associated with the No Action Alternative.

When compared with the No Action Alternative, Alternative 3 would decrease lands subject to fallowing in the San Joaquin River region by 303,764 acres during average water years, which is 9.56% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 210,633 acres of fallowed land, a 6.63% increase of the total irrigated lands subject to erosion. Therefore, the potential for erosion would decrease during average water years and increase during critical and dry water year types.

Bay-Delta Operations

As mentioned above, a minor increase in flow under Alternative 3 is expected through the Delta during January (1,284 TAF); however, this 7 % increase is well below flows during winter flood events through the Bay-Delta. Therefore, erosion is not a substantial concern in this area.

With regards to changes in irrigated acreage, as described in Appendix R, this region was not modeled under SWAP and flows on average would decrease in this region under Alternative 3 compared with the No Action Alternative. Therefore, an increase in lands subject to fallowing is anticipated. The potential for soil erosion would increase compared with the No Action Alternative.

Additional CVP and SWP Service Areas

There are no Reclamation storage reservoirs or affected stream reaches in the CVP and SWP service areas; therefore, erosion as a result in changes to flow is not a concern in these areas.

Flows would increase in this region under Alternative 3, compared with the No Action Alternative. Therefore, no conversion of agricultural land or crop idling is anticipated, and soil erosion caused by these factors would not occur.

W.2.5.2 Potential Changes in Land Subsidence Due to Increased Use of Groundwater

Trinity River

As described in Appendix I, 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; therefore, subsidence is not a concern in this area.

Central Valley

In the Sacramento and San Joaquin Valleys, groundwater levels are generally expected to remain the same or decrease, thereby increasing the potential for additional subsidence to occur at various locations throughout the region. Average simulated groundwater levels indicate that these levels could be as much as 160 feet for Alternative 3 in some water year types compared with the No Action Alternative. The largest decreases in groundwater levels are simulated to occur along the western portion of the Sacramento Valley and San Joaquin Valley. Additional areas of decreased groundwater levels appear north of Modesto and south of Fresno. Given the relatively large decreases in simulated groundwater elevations and the fact that portions of these areas are known to have historic subsidence, the potential for additional subsidence is high. The location and amount of subsidence is highly dependent on the local soil conditions and historical low groundwater levels in the area.

Southern California Region

The Southern California region is not known to be susceptible to subsidence and, as was noted in Appendix I, Section I.2.5.4.4, *Southern California Region*, groundwater pumping is not expected to increase in this region, suggesting that subsidence would not be a concern in this area.

W.2.6 Alternative 4

W.2.6.1 Potential Changes in Soil Erosion

Trinity River

During Alternative 4, both dry and wet periods in Trinity Reservoir would have a negligible negative drawdown in comparison to the No Action Alternative, -32 TAF (-4% change) and -16 TAF (-1% change), as shown in Table W-1. No change in the potential for mass wasting and surface erosion along the shoreline of Trinity Reservoir is expected when compared with the No Action Alternative. Similarly, in reservoir release situations, Alternative 4 during dry periods (-3.7 TAF, -9% change) is less likely to result in erosion of the Trinity River when compared with the No Action Alternative, as shown in Table W-1. Alternative 4 during wet periods is positive though negligible (14 TAF, 2% change). This indicates that there are no changes expected in flow-related erosion of the Trinity River when compared with the No Action Alternative.

No agricultural lands in the Trinity River area are served by CVP and SWP water supplies. Thus, the Trinity River region was not included in the SWAP model used to evaluate effects of the project upon irrigated acreage. No conversion of agricultural land or crop idling is anticipated. Soil erosion due to changes in irrigated acreage is not affected by CVP or SWP activity.

Sacramento Valley

Under Alternative 4, dry periods for Shasta Reservoir would have an increase in drawdown value (134 TAF, 9% change), as shown in Table W-2, resulting in increased potential for shoreline erosion at Shasta Reservoir when compared with the No Action Alternative. During wet periods, Alternative 4 would have an increased drawdown value (7 TAF, approximately 0% change), resulting in negligible changes in shoreline erosion at Shasta Reservoir when compared with the No Action Alternative. Releases into the Sacramento River during both dry (5 TAF, 1% change) and wet (6 TAF, 0% change) periods compared with the No Action Alternative, as shown in Table W-2, are negligible.

Folsom Reservoir drawdown during dry and wet periods has small, negligible negative values (-1 TAF, approximately 0% change), as shown in Table W-3, indicating that Alternative 4 would result in no changes to shoreline erosion around Folsom Reservoir compared with the No Action Alternative. Releases to the American River during both dry and wet periods compared with the No Action Alternative have negative values, -25 (-14% change) and -38 TAF (-1% change), as shown in Table W-3, denoting a lower probability for erosion in dry years of the American River when compared with the No Action Alternative.

The Yolo Bypass carries flood flows that spill from the Sacramento River at the Fremont Weir during large winter storm events, with the highest flows occurring typically December through February. Flows through the Yolo Bypass are expected to increase by 0.5% under Alternative 4 compared with the No Action Alternative, increasing from 28,132 cfs to 28,269 cfs. This minor increase in winter flood flows through the Yolo Bypass would result in negligible riverine erosion given the low channel gradient, large cross-sectional area for flow, and low flow velocities at the margins of the bypass.

When compared with the No Action Alternative, Alternative 4 would decrease lands subject to fallowing in the Sacramento River region by 1,316 acres during average water years, which is 0.06% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 814 acres of fallowed land, a 0.04% increase of the total irrigated lands subject to erosion. Therefore, there would be a decrease in the potential for erosion during average water years and an increase in the potential for erosion during critical and dry water year types.

San Joaquin Valley

Under Alternative 4, dry periods would be negligible negative drawdown values for New Melones Lake (-5 TAF, -1% change), as shown in Table W-4, indicating a smaller potential for mass wasting and surface erosion around the shoreline when compared with the No Action Alternative. However, during wet periods, Alternative 4 has a negligible positive drawdown (24 TAF, 1% change), resulting in no changes in shoreline erosion when compared with the No Action Alternative. Releases to the Stanislaus River would be positive during dry periods (3 TAF, 7% change) and negligible during wet periods (22 TAF, 3% change), as shown in Table W-4, indicating a greater potential for erosion of the Stanislaus River high flow in dry periods when compared with the No Action Alternative.

Under Alternative 4, there would be no changes to the operation of Millerton Reservoir, nor releases to the San Joaquin River, relative to the No Action Alternative, as shown in Table W-5. Therefore, there would be no impacts related to shoreline erosion surrounding Millerton Reservoir or flow erosion of the San Joaquin River beyond those associated with the No Action Alternative.

When compared with the No Action Alternative, Alternative 4 would decrease lands subject to fallowing in the San Joaquin River region by 14,094 acres during average water years, which is 0.06% of the total irrigated lands subject to surface erosion throughout the region. During the average of critical and dry water year types, there would be an increase of 10,343 acres of fallowed land, a 0.33% increase of the total irrigated lands subject to erosion. Therefore, the potential for erosion would decrease during average water years and increase during critical and dry water year types.

Bay-Delta Operations

No changes in flows are expected in the Bay-Delta region under Alternative 4 compared with the No Action Alternative; therefore, stream channel erosion associated with Alternative 4 would not occur in this area. Changes in flows are not expected in the Suisun Marsh or the San Francisco Bay under Alternative 4; therefore, there is no expected change to erosion rates.

Flows on average would increase by 1% in this region under Alternative 4 compared with the No Action Alternative. Therefore, a decrease in lands subject to fallowing is anticipated. The potential for soil erosion would decrease compared with the No Action Alternative.

Additional CVP and SWP Service Areas

There are no Reclamation storage reservoirs or affected stream reaches in the CVP and SWP service areas; therefore, erosion as a result in changes to flow is not a concern in these areas.

There are no affected stream reaches associated with the Central Coast or Southern California regions; therefore, erosion as a result of changes to flow is not a concern in this area.

Flows would increase in this region under Alternative 4 compared with the No Action Alternative. No conversion of agricultural land or crop idling is anticipated under Alternative 4, and soil erosion caused by these factors would not occur.

W.2.6.2 Potential Changes in Land Subsidence Due to Increased Use of Groundwater

Trinity River

As described in Appendix I, 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; therefore, subsidence is not a concern in this area.

Central Valley

In the Sacramento and San Joaquin Valleys, average simulated groundwater levels are generally expected to decrease up to 7 feet in certain water year types under Alternative 4 compared with the No Action Alternative. The largest decreases in these simulated groundwater levels occur along the western portion of the Sacramento Valley. The relatively small decreases in groundwater levels are not expected to cause large amounts of additional subsidence. However, portions of these areas are known to have historic subsidence, and additional decreases in groundwater elevation may induce additional localized subsidence. The location and amount of subsidence is highly dependent on the local soil conditions and historical low groundwater levels in the area. It is unlikely that Alternative 4 would cause additional subsidence compared with the No Action Alternative.

Southern California Region

The Southern California region is not known to be susceptible to subsidence, and as noted in Appendix I, Section I.2.6.4.4, *Southern California Region*, groundwater pumping is not expected to increase in this region under Alternative 4. Thus, subsidence is not expected to be a concern in this area.

W.2.7 Mitigation Measures

No avoidance and minimization measures or mitigation measures have been identified for geology and soils.

W.2.8 Summary of Impacts

Table W-6 includes a summary of impacts, the magnitude and direction of those impacts, and potential mitigation measures for consideration.

Table W-6. Impact Summary

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
Potential Changes in Soil Erosion and Mass Wasting	No Action	No Impact	--
	Alternative 1	Under both dry and wet conditions, the drawdown is negligible, and the Trinity Reservoir Storage will not see changes in surface erosion and mass wasting. The Trinity River Release's values are negligible both dry and wet periods. In the Sacramento Valley region, in both dry and wet periods, Shasta Reservoir is not expected to see changes of surface erosion and mass wasting because drawdown is negligible. Folsom Reservoir will see an increase of erosion and mass wasting in dry periods and see no change in wet periods. The Sacramento River Release will see no changes in surface erosion and mass wasting in dry periods or wet periods because drawdown is negligible. The American River Release will also see a decreased likelihood of surface erosion and mass wasting in dry periods and no change in wet periods. In the San Joaquin Valley, New Melones Reservoir will see periods of no changes in wet or dry periods because the drawdown is negligible. The Stanislaus River Release will see an increased likelihood of surface erosion and mass wasting in both wet and dry periods. Millerton Reservoir and the San Joaquin River Release will see no changes in erosion. There are no expected changes to erosion under Alternative 1 in the Bay-Delta region.	--
	Alternative 2	In Trinity Reservoir, under all phases of Alternative 2 in both dry and wet periods, there are no changes to likelihood of surface erosion and mass wasting because the drawdown values	--

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
		are negligible. The Trinity River Release sees a decreased likelihood of surface erosion and mass wasting in dry periods for all phases. In wet periods, all phases of the drawdown are negligible and, thus, there is no change in surface erosion and mass wasting expected. In the Sacramento Valley at Shasta Reservoir in dry periods, all phases of Alternative 2 show an increased likelihood of a surface erosion and mass wasting period. There are no changes expected under wet periods because drawdown is negligible. The Sacramento River Release, in both dry and wet periods, sees no likelihood of changes of surface erosion and mass wasting for all phases because drawdown is negligible. At Folsom Reservoir, it is not expected to see changes in both dry and wet periods for all phases. In American River Releases, all phases in dry periods see a decreased likelihood of surface erosion and mass wasting. Wet periods will see no change in erosion because drawdown is negligible. In the San Joaquin Valley, New Melones Reservoir sees no changes in period surface erosion and mass wasting in dry and wet periods for all phases because drawdown is negligible. Stanislaus River Releases will see an increased likelihood of surface erosion and mass wasting in dry periods and negligible changes in wet periods for all phases. Millerton Reservoir and San Joaquin River Release see no changes in erosion for all phases in both wet and dry periods. There are no expected changes to erosion under Alternative 2 (all phases) in the Bay-Delta region. There are no Reclamation storage reservoirs or affected stream reaches in the CVP and	

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
		SWP service areas, thus erosion will not be affected by Alternative 2 (all phases).	
	Alternative 3	At Trinity Reservoir, there is a higher likelihood of surface erosion and mass wasting in dry periods compared with the No Action Alternative. The drawdown is negligible in wet periods. Trinity River Releases will see an increased likelihood of surface erosion and mass wasting in wet periods and a lower likelihood in dry periods. In the Sacramento Valley, Shasta Reservoir sees an increased likelihood of surface erosion and mass wasting in dry periods but no changes in wet periods. Sacramento River Releases sees no changes in surface erosion and mass wasting in both wet and dry periods. Folsom Reservoir storage shows no changes in likelihood of erosion and mass wasting in dry and wet periods. American River Release sees a decreased likelihood of surface erosion and mass wasting in dry periods and no change in wet periods. In the San Joaquin Valley, New Melones Reservoir will see no changes in surface erosion and mass wasting in dry periods and wet periods because drawdown is negligible. Stanislaus River Releases will see an increased likelihood of surface erosion and mass wasting in both wet periods and negligible changes in dry periods. Millerton Reservoir and San Joaquin River Releases will see little to no changes in erosion. Though there is a minor increase in flow through the Bay-Delta region from Alternative 3, compared with the No Action, erosion is not a substantial concern in this area. There are no Reclamation storage reservoirs or affected stream reaches in the CVP and SWP service areas, thus	--

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
		erosion will not be affected by Alternative 3.	
	Alternative 4	Trinity Reservoir in both dry and wet periods sees no change in likelihood of surface erosion and mass wasting because drawdown values are negligible. Trinity River Releases sees no change of surface erosion and mass wasting in wet periods because the drawdown is negligible, and a decreased likelihood in dry periods. In the Sacramento Valley, Shasta Reservoir Storage sees an increased likelihood of surface erosion and mass wasting in dry periods and no changes in wet periods because drawdown is negligible. The Sacramento River Releases sees no changes of surface erosion and mass wasting in both wet and dry periods because drawdown is negligible. Folsom Reservoir sees no changes in the likelihood of surface erosion and mass wasting in both wet and dry periods because drawdown is negligible. American River Releases sees a decreased likelihood of surface erosion and mass wasting dry periods and no changes in wet periods because drawdown is negligible. In the San Joaquin Valley, New Melones Reservoir shows no changes to surface erosion and mass wasting in dry and wet periods because drawdown is negligible. Stanislaus River Releases will see an increased likelihood of surface erosion and mass wasting in dry periods and negligible changes in wet periods. Millerton Reservoir and the San Joaquin River Release will see no changes to erosion. There are no expected changes to erosion under Alternative 4 in the Bay-Delta region. There are no Reclamation storage reservoirs or affected stream	--

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
		reaches in the CVP and SWP service areas, thus erosion will not be affected by Alternative 4.	
Potential Changes in Irrigated Acreage	No Action	No impact	--
	Alternative 1	Under Alternative 1, lands in the Trinity River region are not served by CVP and SWP water supplies, thus, no conversion of agricultural land or crop idling is anticipated. In both the Sacramento Valley and the San Joaquin Valley, the lands subject to fallowing are anticipated to decrease, thus erosion is likely to decrease. The Bay-Delta Operations, and CVP and SWP Service Areas, will not see impacts related to changes in irrigated acreage.	--
	Alternative 2	Under Alternative 2, lands in the Trinity River region are not served by CVP and SWP water supplies, thus, no conversion of agricultural land or crop idling is anticipated. The Sacramento Valley would see an increase in fallowing and thus an increase in erosion for all phases. San Joaquin Valley would see an increase in fallowing and thus an increase in erosion for all phases. It is anticipated that the Bay-Delta Operations will see an increase in fallowing of agricultural land, thus the potential for soil erosion would increase. The CVP and SWP Service Areas will not see impacts related to changes in irrigated acreage.	--
	Alternative 3	Under Alternative 3, lands in the Trinity River region are not served by CVP and SWP water supplies, thus, no conversion of agricultural land or crop idling is anticipated. The Sacramento Valley is anticipated to see an increase in lands subjected to fallowing, thus the likelihood for erosion would increase.	--

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
		In the San Joaquin Valley, fallowing would decrease in average wet periods, decreasing the likelihood of erosion. In critical and dry periods, fallowing would increase, increasing the total irrigated lands subject to erosion. It is anticipated that the Bay-Delta Operations will see an increase in fallowing of agricultural land, thus the potential for soil erosion would increase. The CVP and SWP Service Areas will not see impacts related to changes in irrigated acreage.	
	Alternative 4	Under Alternative 4, lands in the Trinity River region are not served by CVP and SWP water supplies, thus, no conversion of agricultural land or crop idling is anticipated. In both the Sacramento Valley and San Joaquin Valley, fallowing would decrease in average wet periods, decreasing the likelihood of erosion. In critical and dry periods, fallowing would increase, increasing the total irrigated lands subject to erosion. It is anticipated that the Bay-Delta Operations will see a decrease in fallowing of agricultural land, thus the potential for soil erosion would decrease. The CVP and SWP Service Areas will not see impacts related to changes in irrigated acreage.	--
Potential Changes in Land Subsidence	No Action	No Impact	--
	Alternative 1	It is not anticipated that the Trinity River region will see impacts related to potential land subsidence. The Sacramento Valley, San Joaquin Valley, Bay-Delta Operations, and CVP and SWP Service Areas will not see impacts related to land subsidence.	--

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	Alternative 2	It is not anticipated that the Trinity River region will see impacts related to potential land subsidence. In the Sacramento and San Joaquin Valleys, average groundwater levels are generally expected to remain the same or decrease under all phases. The Bay-Delta Operations, and CVP and SWP Service Areas, will not see impacts related to potential land subsidence.	--
	Alternative 3	It is not anticipated that the Trinity River region will see impacts related to potential land subsidence. In the Sacramento and San Joaquin Valleys, average groundwater levels are generally expected to remain the same or decrease. The Bay-Delta Operations, and CVP and SWP Service Areas, will not see impacts related to potential land subsidence.	--
	Alternative 4	It is not anticipated that the Trinity River region will see impacts related to potential land subsidence. In the Sacramento and San Joaquin Valleys, average groundwater levels are generally expected to remain the same or decrease. The Bay-Delta Operations, and CVP and SWP Service Areas, will not see impacts related to potential land subsidence.	--

W.2.9 Cumulative Impacts

Past, present, and reasonably foreseeable projects, described in Appendix Y, *Cumulative Impacts Technical Appendix*, may have cumulative effects on geology and soils, to the extent that they could affect agricultural land fallowing, soil erosion and the rate of land subsidence.

Past and present actions contribute to the existing condition of the affected environment in the project area while reasonably foreseeable actions are those that are likely to occur in the future that are not speculative. Past, present, and reasonably foreseeable projects include actions to develop water storage capacity, water conveyance infrastructure, water recycling capacity, the reoperation of existing water supply infrastructure, including surface water reservoirs and conveyance infrastructure, and habitat restoration actions.

The projects identified in Appendix Y that have the most potential to contribute to cumulative impact on geology and soils are related to water supply (e.g. B.F. Sisk Dam Raise and Reservoir Expansion Project, Bay-Delta Water Quality Control Plan Update, Los Vaqueros Reservoir Expansion Phase 2, and habitat restoration).

The No Action Alternative would continue with the current operation of the CVP and may result in potential changes in geology and soils resources at reservoirs that store CVP water, tributaries, and agricultural land across the CVP and SWP service area.

W.2.9.1 Potential Changes in Soil Erosion

Trinity River

In this region, Alternative 3 under dry conditions is the only scenario in which shoreline and riverine erosion may increase relative to the No Action Alternative. Therefore Alternative 3 under dry conditions may minimally contribute to the cumulative soil erosion condition in this region. Changes in reservoir storage and river releases under Alternative 1, all phases of Alternative 2, Alternative 3 under wet conditions, and Alternative 4 would have either a negligible impact on or would lessen the cumulative condition for geology and soils in this area.

Central Valley

For Shasta Reservoir, Alternatives 2, 3 and 4, all under dry conditions, are the scenarios in which shoreline erosion may increase relative to the No Action Alternative. Therefore, these conditions may contribute to the cumulative soil erosion condition in this region. Changes in shoreline erosion under Alternative 1 and under wet conditions for Alternatives 2, 3, and 4 would be negligible and would therefore have minimal impact on the cumulative condition for geology and soils in this area. Changes in riverine erosion for all action alternatives would be negligible and would therefore have minimal impact on the cumulative condition for geology and soils in this area.

For Folsom Reservoir, Alternative 1 under dry conditions is the only scenario in which shoreline erosion may increase relative to the No Action Alternative; this alternative may minimally contribute to the cumulative soil erosion condition in this region. Changes in shoreline erosion for Alternative 1 under wet conditions and Alternatives 2, 3, and 4 would be negligible and would therefore have minimal impact on the cumulative condition for geology and soils in this area. Changes in riverine erosion for Alternatives 1, and under wet conditions for Alternatives 2, 3, and 4 would be negligible and would therefore have minimal impact on the cumulative condition for geology and soils in this area. Changes in riverine erosion under dry conditions for Alternatives 2, 3, and 4 would decrease and would therefore less the impact on the cumulative condition for geology and soils in this area.

Compared to the No Action Alternative, Alternative 3 had the largest increase in lands that would be subject to fallowing in the Sacramento River Region (average year = 1.11%), which would increase the potential for wind erosion. Changes in wind erosion would contribute to the cumulative condition for geology and soils in this area.

Bay-Delta Region

For the Bay-Delta region, no changes in riverine erosion would occur under Alternatives 1, 2 and 4 relative to the No Action Alternative. Therefore, it is unlikely these alternatives would contribute to the cumulative soil erosion condition in this region. A minor increase in flow under Alternative 3 is expected through the Bay-Delta Region during January; however, this increase is within the range of high flows through the Bay-Delta Region during winter flood events through the Bay-Delta; therefore, riverine erosion is not a substantial concern but may contribute to the cumulative soil erosion condition in this region.

No conversion of agricultural land or crop idling is anticipated, and erosion of fallowed land would not change compared with the No Action Alternative. Under all phases of Alternative 2 and Alternative 3, agricultural flows to the San Francisco Bay Area would decrease, which could result in erosion of fallowed land. Under Alternative 4, agricultural flows to the San Francisco Bay Area would increase, which could increase erosion of fallowed land. These scenarios may contribute to the cumulative soil erosion condition of this region.

San Joaquin Valley

Releases to the Stanislaus River would result in negligible increases during wet periods under Alternatives 2 and 4. Alternatives 1 and 4 would result in increases of 7% and 10 %, respectively, which could increase the potential for channel erosion slightly. During dry periods, Alternative 3, channel erosion would be negligible; however, Alternatives 1, 2, and 4 would have a slight increase in potential (4-% to 13 %) for channel erosion. These scenarios may contribute to the cumulative soil erosion condition of this region.

Additional CVP and SWP Service Areas

There are no Reclamation storage reservoirs or affected stream reaches in the additional CVP and SWP service areas; therefore, erosion of fallowed land would not change relative to the No Action Alternative and would not contribute to the cumulative soil erosion condition of this region.

W.2.9.2 Potential Changes in Land Subsidence Due to Increased Use of Groundwater

Numerous groundwater storage and recovery projects are proposed or have been completed (Appendix Y). However, these projects largely involve groundwater banking, in which water is stored in groundwater and then withdrawn. Therefore, they would not exacerbate land subsidence. Additionally, the Eastern San Joaquin Integrated Conjunctive Use Program would support groundwater recharge and include groundwater banking, as described in Appendix Y, in part to address groundwater overdraft. There are also several projects meant to benefit agricultural users, such as the South Delta Temporary Barriers Project and the Red Bluff Diversion Dam Fish Passage Improvement Project. Most action alternatives would result in no change in groundwater levels and no impact on subsidence. Alternative 2 (in some phases), Alternative 3, and Alternative 4 could decrease groundwater levels in the Sacramento and San Joaquin Valleys. However, the location and amount of subsidence is highly dependent on the local soil conditions and historical low groundwater levels in the area. Given that many of the reasonably foreseeable projects have the stated intent to address groundwater overdraft and agricultural supply, cumulative land subsidence impacts would not be exuberated.

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