Chapter 7 Fluvial Geomorphology

7.1 Introduction

This chapter describes the environmental setting, methods of analysis, and impact analysis for fluvial geomorphology that would potentially be affected by the construction and operation of the Project. Fluvial geomorphology is a discipline that examines river processes (e.g., scour and deposition) and landforms (e.g., channel bed, channel banks, and floodplains), and the relationships between them. The study area for fluvial geomorphology consists of the local drainages associated with the Sites Reservoir (e.g., Funks, Stone Corral, and Hunters Creeks), as well as downstream waterbodies such as the Sacramento River and the Yolo Bypass. Engineered drainage canals (i.e., TC Canal, GCID Main Canal, and CBD) are also included in the study area. Other watercourses and flood storage facilities associated with northern California's water delivery and flood management infrastructure, such as the Trinity River, Feather River, American River, and San Luis Reservoir are not discussed below because, based on the various modeling results available for the Project, there would be no construction geomorphic impacts within these areas and operational geomorphic effects associated with the Project would have minimal or no impact on these watercourses and flood storage facilities.

Tables 7-1a and 7-1b summarize the CEQA determinations and NEPA conclusions for construction and operation impacts, respectively, between alternatives that are described in the impact analysis.

Table 7-1a. Summary of Construction Impacts and Mitigation Measures for Fluvial Geomorphology

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact FLV-1: Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would result in a substantial increase or decrease in on- or off-site erosion or siltation			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FLV-2: Substantially alter natural river geomorphic processes (i.e., flow regime, sediment transport, and bank erosion) and existing river geomorphic characteristics (i.e., sinuosity, channel gradient, substrate composition, channel width and depth, and riparian vegetation)			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FLV-3: Substantially alter the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel in Funks and Stone Corral Creeks downstream of Sites Reservoir			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FLV-4: Substantially alter geomorphic processes upstream of the dam sites			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE

Notes:
NI = CEQA determination of no impact
LTS = CEQA determination of less-than-significant impact
LTSM = CEQA determination of less than significant with mitigation
SU = CEQA determination of significant and unavoidable
B = NEPA conclusion of beneficial effects
NE = NEPA conclusion of no effect or no adverse effect
AE = NEPA conclusion of adverse effect
SA = NEPA conclusion of substantial adverse effect

Table 7-1b. Summary of Operation Impacts and Mitigation Measures for Fluvial Geomorphology

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact FLV-1: Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would result in a substantial increase or decrease in on- or off-site erosion or siltation			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FLV-2: Substantially alter natural river geomorphic processes (i.e., flow regime, sediment transport, and bank erosion) and existing river geomorphic characteristics (i.e., sinuosity, channel gradient, substrate composition, channel width and depth, and riparian vegetation)			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact FLV-3: Substantially alter the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel in Funks and Stone Corral Creeks downstream of the Sites Reservoir			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FLV-4: Substantially alter geomorphic processes upstream of the dam sites			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE

Notes:
NI = CEQA determination of no impact
LTS = CEQA determination of less-than-significant impact
LTSM = CEQA determination of less than significant with mitigation
SU = CEQA determination of significant and unavoidable
B = NEPA conclusion of beneficial effects
NE = NEPA conclusion of no effect or no adverse effect
AE = NEPA conclusion of adverse effect
SA = NEPA conclusion of substantial adverse effect

7.2 Environmental Setting

This section describes the geomorphology of the watercourses in the study area from upstream to downstream. These watercourses consist of the local drainages in proximity to Antelope Valley and the inundation area, and downstream waterbodies such as the Sacramento River, CBD, Delta, and Yolo Bypass. Appendix 7A, *Fluvial Geomorphic Setting Information*, provides detailed information on the environmental setting for fluvial geomorphology of the waterbodies in the study area, including the reaches of the Sacramento River, the Delta, and the Yolo Bypass.

7.2.1. Drainages in Proximity to Antelope Valley

The drainages in proximity to Antelope Valley consist of creeks that are upstream of and within the valley, and the creeks that are downstream of the valley. Grapevine, Antelope, Funks, Stone Corral, and Hunters Creeks are upstream of and within Antelope Valley. Funks and Stone Corral Creeks exit Antelope Valley and their downstream reaches are in the Sacramento Valley. Figures 1-2 and 1-3 in Chapter 1, *Introduction*, identify the locations of these creeks. The geologic and topographic setting, and geomorphic characteristics associated with these drainages are discussed below.

7.2.1.1. Geologic and Topographic Setting

The Antelope Valley soils are in the Coast Ranges geomorphic province and have formed in place from weathered rock, colluvium, and alluvium (Soil Survey Staff 2020). Most of the soils in the Antelope Valley are clayey and have high expansion potential. The soils are shallow to very deep and have a slight to moderate water erosion hazard (Soil Survey Staff 2020). A stream-cut water gap on Funks Creek is in the Venado sandstone member of the Cortina Formation. The lower portion of the channel is in the Yolo member of the Cortina Formation. The stream-cut water gap on Stone Corral Creek is in the Boxer and Cortina Formations.

Antelope Valley is characterized as a gently sloping valley with some subtly rounded knolls, mainly in the vicinity of the saddle dams. It is drained primarily by easterly flowing Funks and Stone Corral Creeks, with some minor northeasterly flowing drainages in the northwestern part of the reservoir. Most of the inundation area is level or consists of gentle slopes (up to 3%), but the slopes in the vicinity of the Golden Gate and Sites Dams, saddle dams, and saddle dikes mostly range from 15% to 75% (AECOM 2020:8).

7.2.1.2. Drainage Geomorphic Characteristics

The study area contains multiple drainages that originate in the eastside foothills of the Coast Range, including Grapevine, Antelope, Funks, Stone Corral, and Hunters Creeks. Table 7-2 summarizes the characteristics of these drainages.

Table 7-2. Drainage Geomorphic Characteristics Summary

Creek Name	Location, Flow Direction, and Approximate Length	Water Regime	Planform	Primary Habitat Unit[a]	Channel Substrate[a]
Upstream of Antelope Valley					
Grapevine Creek	Creek flows north/northeast for 14.5 miles until confluence with Funks Creek.	Ephemeral	Slightly sinuous	Pool	Small cobble and gravel
Antelope Creek	Creek flows from Calvin Creek confluence through south Antelope Valley for 9.9 miles until joining Stone Corral Creek.	Ephemeral	Slightly sinuous	Flatwater	Silt and clay
Funks Creek	Headwater tributaries converge northwest of the reservoir footprint. Creek flows southeast for 3.7 miles until confluence with Grapevine Creek.[b]	Ephemeral to intermittent	Slightly sinuous	Flatwater	Gravel
Stone Corral Creek	Headwater tributaries converge along the Sites Lodoga Road; creek flows in southeast for 4.1 miles until confluence with Antelope Creek.	Ephemeral	Slightly sinuous	Flatwater	Bedrock

Creek Name	Location, Flow Direction, and Approximate Length	Water Regime	Planform	Primary Habitat Unit[a]	Channel Substrate[a]
Hunters Creek	Headwaters north of Antelope Valley flow east into Sacramento Valley. There are four forks of this creek. The north fork is the longest (9.0 miles) and drains into the TC Canal. The other three forks converge into the north fork.	Ephemeral	Slightly sinuous	–	–
Downstream of Antelope Valley					
Funks Creek	Creek flows 1.8 miles downstream of the proposed Golden Gate Dam to Funks Reservoir, then flows 3.8 miles to the GCID Main Canal, then 2.4 miles to I-5[c], after which it confluences with Stone Corral Creek, roughly 3.5 miles downstream and southeast of I-5.	Intermittent	N/A[d]	–	–
Stone Corral Creek	Creek flows 4.7 miles to the TC Canal, then roughly 3.0 miles to the GCID Main Canal, after which it continues 4.1 miles to I-5 then another 1.4 miles to its confluence with Funks Creek, and finally terminating in 5.6 miles at the CBD.	Intermittent	N/A[d]	–	–

Notes: a = Brown 2000
b = Distance between confluence and Golden Gate Dam is approximately 5.4 miles
c = Interstate 5
d = channel has been modified and largely straightened along the Sacramento Valley floor.
–- = no data

7.2.2. Other Valley Drainages

The other valley floor drainages in the study area that would be directly or indirectly affected by the Project are Walker Creek, Willow Creek, and Bird Creek.

Walker and Willow Creeks (where siphon replacements would occur) are valley streams, possibly intermittent, whose headwater-contributing channels originate in the foothills northwest of the GCID Main Canal. Similar to other valley floor channels in the study area, these creeks transition from more natural channels to highly disturbed and channelized drainages a few miles before flowing under Interstate 5 (I-5).

Bird Creek exits the Coast Range foothills and drains in an easterly direction into the CBD. Based on geographical similarities between Funks and Stone Corral Creeks (i.e., drainage area, longitudinal position within the local drainage network, and observable geomorphic characteristics), Bird Creek is considered an intermittent stream. Approximately 0.25 mile west of I-5, Bird Creek transitions from more of a natural channel to a highly disturbed and channelized drainage that flows under I-5, extends through rice fields, and discharges into the CBD.

7.2.3. Sacramento River

The geomorphology of the Sacramento River varies through the region. The river transitions from a narrow and deep canyon environment (with a similarly narrow floodplain) in its upper reaches below Shasta Lake (i.e., the Keswick Dam to Red Bluff reach, further described below) to a meandering, shallower system with a broader alluvial floodplain in its lower reaches. The Sacramento River historically meandered across a wide floodplain. By geomorphic processes such as erosion and deposition, the river migrated across the deep alluvial soils from the Red Bluff area to about Chico Landing. At River Mile (RM) 190, the river has its confluence with Stony Creek (a western tributary). From this point downstream, high flows along the Sacramento River were historically divided between its mainstem and the adjacent flood basins (which were separated from the mainstem by natural levees).

The Sacramento Valley flood basins have been, and continue to be, primary influences on the hydrogeomorphic evolution of the Sacramento River and other watercourses in the study area. Most notably, these overflow areas cause the Sacramento River to get smaller downstream. In addition, suspended sediment that historically has been deposited in the flood basins has generated a thick, cohesive stratigraphic unit, which adds to the bank stability of the lower Sacramento River. The significance of these flood basin deposits increases downstream as the topographic lows become more pronounced between Chico and Verona (Water Engineering and Technology 1990:34–35). Because of these natural geomorphic processes, the riverbanks of the Sacramento River are generally higher than the surrounding floodplains. The stream power of flood flows in the mainstem Sacramento River has resulted in several distributary flood paths across the flat valley floor.

Today, both base flows and peak flows have been regulated to the extent that they limit natural geomorphic and ecosystem functions. Channel migration, meander cutoff and oxbow formation processes, and other smaller-scale geomorphic processes that operated in the past are limited by the presence of dams and levee construction.

7.2.3.1. Sedimentation

Under historical (i.e., unaltered) conditions, the Sacramento River lacked the capacity to carry the peak discharge events generated by winter season precipitation. Overbank flooding was commonplace. As flow velocity in the overbank areas was reduced, the sediment transport capacity was also lowered, thus allowing a large portion of the transported sediment to be deposited onto these overbank areas. The Sacramento River formed natural levees composed of the coarser substrate carried by the larger flows each year, while the finer material stayed in suspension longer and settled out into the flood basins.

Both the flow regime and the sediment transport and deposition regimes in the Sacramento River have been significantly altered from historical conditions due to anthropogenic modifications. Many of the river levees were originally intended to decrease channel width to promote higher flow velocities that would perpetuate scouring large amounts of hydraulic mining sediments to deepen the channel for navigation. The narrow channels contribute to the self-eroding phenomena of the levees (stream energy is essentially directed towards the banks), which necessitates the need for constant levee maintenance. To protect from bank erosion, many levees are armored with large angular boulders (i.e., rock slope protection or riprap).

7.2.3.2. Regional Geomorphic Description

For the purposes of this chapter, the Sacramento River is divided into the same valley reaches[1] used in Chapter 5, *Surface Water Resources* (Figure 7-1). The diversions and re-entry points associated with the Project are located between Keswick Reservoir and Verona. Accordingly, the highest potential for change to the geomorphic regime of the Sacramento River would occur in these reaches:

- Keswick Dam to Red Bluff reach (RM 302 to RM 246)
- Red Bluff to Chico Landing reach (RM 246 to RM 194)
- Chico Landing to Colusa reach (RM 194 to RM 143)
- Colusa to Verona reach (RM 143 to RM 79)

The Keswick Dam to Red Bluff reach includes flows upstream of the Project diversions[2]. The Red Bluff to Chico Landing reach and the Chico Landing to Colusa reach contain all of the diversions that would be implemented under the Project. The Colusa to Verona reach is located downstream of the diversions and the ensuing stream discharges that would be implemented under the Project.

The Sacramento River discharge would be located in the Colusa to Verona reach of the Sacramento River between RMs 100 and 101). This reach is mostly confined by levees but there are locations where the levees are set back to provide overflow across point bars of major meander bends (e.g., Tyndall Landing). The location of the Sacramento River discharge shows no evidence of historical meandering and average channel width has only increased about 4% between 1987 and 2005 upstream of the Feather River confluence.

7.2.4. Colusa Basin Drain

Landforms within the Colusa Basin include the levees along the west side of the Sacramento River and the large floodplains and flood basins on the valley floor. A low trough of relatively

[1] Regional geomorphic descriptions for the Keswick Dam to Red Bluff and Red Bluff to Chico Landing reaches of the Sacramento River are summarized mainly from Chapters 3 and 4 of the Hydraulics section of the *Sacramento River Conservation Area Forum Handbook* (California Resources Agency 2003).

[2] Fluvial geomorphic conditions in this reach are presented for information purposes only, as this reach would not be affected by the Project.

flat flood basins parallels the Sacramento River levees. The geomorphology of the Colusa Basin has been modified since via Euro-American settlement with the development of flood control facilities and water supply projects (H. T. Harvey & Associates et al. 2008:1). The CBD is the largest engineered drainage structure in the Colusa Basin. Eroded sediments from the adjacent agricultural areas are ultimately transported to the CBD, which has an outlet to the Sacramento River through the Knights Landing Ridge Cut and the Yolo Bypass.

7.2.4.1. Knights Landing Ridge Cut

The Knights Landing Ridge Cut conveys CBD drainage and flood flows into the Yolo Bypass several miles downstream of Fremont Weir. It is an entirely engineered drainage, approximately 8 miles long from its inception at the CBD to where it enters the Yolo Bypass. From the top of its surrounding levees, its width averages approximately 575 feet.

7.2.5. Delta and Yolo Bypass

The present geomorphic state of the Delta is a function of the intensity of water management in each of the tributary rivers, local farming practices, intra- and inter-Delta water transfers, and an extensive human-made levee system. Today, channel alignments are largely fixed by artificial levees and erosion control measures. Flooding, except when artificial levees break, no longer occurs on most islands and tracts. Instead, flow and sediment remain confined to the existing channel network. Upstream water diversions for municipalities and agriculture reduce the amount of flow entering the Delta and the amount of sediment transported to the Delta. In addition, conveyance of water within and out of the Delta alters flow directions and affects sedimentation and erosion rates and patterns. The levee system in the Delta restricts flow to a network of human-made and natural channels that reduce flood events and inhibit the accumulation of soils on the Delta islands.

7.2.5.1. Sediment Inputs

The Sacramento River Flood Control Project conveys released reservoir waters from various upstream sources and stormwater runoff through the Delta and into San Francisco Bay. These waters contain dissolved and undissolved solids, both of which are transported through the system. Undissolved solids (i.e., sediment) consist primarily of clay-, silt-, and sand-sized particles. Before construction of the flood control and conveyance system, the natural flow of freshwater runoff from the upstream mountainous regions transported significant quantities of silt and clay particles. Because of the wide expanse and flat terrain of the Delta area, these particles settled and formed the deposits of the Delta alluvial plain. During the wet season, when the volume of runoff water was much larger, the quantity of suspended and unsuspended solids was significant and included sands and gravels.

The natural processes described above continue in the present day but in a modified manner. Much of the naturally eroded and transported solid particles now settle out in instream water storage reservoirs. A percentage of the fine solids (e.g., silts and clays) are still transported during water releases that enter the system from waterways downstream of the reservoirs. These sediments enter the Delta channels, and rather than settling out in the alluvial plain (as occurred before the channels were constructed), they now remain within the leveed channels.

7.3 Methods of Analysis

The evaluation of physical environmental impacts on with fluvial geomorphology is both quantitative (using and interpreting modeling results) and qualitative (using information about local fluvial geomorphology to establish context and impact mechanisms). The following sections outline the processes used in the determination of impacts on fluvial geomorphology associated with construction and operation of the Project.

7.3.1. Construction

Construction impacts are evaluated qualitatively based on the physical characteristics of the locations where construction would occur, including slope and soil type. Where appropriate, the impact analysis is combined for Alternatives 1, 2, and 3 depending on the impact being evaluated or the associated Project components. The BMPs described in Appendix 2D, *Best Management Practices*, are incorporated into the analysis of potential construction impacts on fluvial geomorphology, including the erosion and sediment control measures under the description of the Stormwater Pollution Prevention Plan(s) (SWPPP) under Stormwater Construction General Permit coverage, and drainage evaluations, design, and implementation. These BMPs minimize alterations to existing drainage infrastructure and patterns where needed.

7.3.2. Operation

Operational impacts of Alternatives 1, 2, and 3 were evaluated quantitatively and qualitatively using the modeled results. The USRDOM model is a non-predictive model that simulates daily river flows in the Sacramento River basin based on the operations specified by the CALSIM II model for Alternatives 1, 2, and 3. The USRDOM model utilizes results from CALSIM II to evaluate the impacts of changing diversions, in-basin use, and Delta operations under projected conditions within current or future regulatory and operational regimes. The model integrates the downstream monthly operational decisions in CALSIM II with a simulation of the associated sub-monthly operational response at Shasta Lake depending on the inflows. This approach is particularly useful in verifying the CALSIM II simulated river conditions and the availability of excess flows to fill the Sites Reservoir under the capacity and operational constraints of the diversions at the Red Bluff and Hamilton City locations.

The USRDOM model description and results are included in Appendix 5C, *Upper Sacramento River Daily River Flow and Operations Modeling*. Detailed discussion of the CALSIM II model is provided in Appendix 5B, *Water Resources System Modeling*. The USRDOM modeled flood flows are compared for each alternative, as well as the No Action Alternative, at key diversion and return locations across the study area. The flood metrics evaluated are monthly average flows exceeded 10% of the time because this is the percent of time during which flows are relatively high and most of the geomorphic work would be performed on the Sacramento River system.

Geomorphic processes are spatially and temporally variable throughout a river system and determining the exact locations of expected geomorphic change is difficult without the aid of rigorous one-dimensional or two-dimensional hydraulic modeling that includes variables such as changes in depth, velocity, and shear stress. Suspended sediment transport, bedload, and river meandering models were previously utilized in the 2017 Draft EIR/EIS for a 1.8-MAF reservoir with a Delevan intake/discharge location. The previous modeled results are valid for the scale at which impacts on fluvial geomorphology are being considered for Alternatives 1, 2, and 3. The previous modeling results are generally conservative (i.e., higher in volume) relative to the amount of diverted water (and sediment) being considered under Alternatives 1, 2, and 3. The previous modeling is summarized below and was applied and incorporated in the impact analysis under Impacts FLV-1 and FLV-2.

Results from a suspended sediment transport model and bedload analysis were reviewed and incorporated into the impact analysis (Appendix 7B, *Hydrodynamic Geomorphic Modeling Results*). A suspended sediment transport model evaluated the movement of sediment in the Sacramento River and estimated the amount of sediment that would be diverted under Alternatives 1, 2, and 3. The USRDOM model results for simulated daily flows were used in conjunction with actual U.S. Geological Survey gaging station sediment sampling results to develop a flow versus suspended sediment rating curve using the SRH-Meander model. The rating curve was then used to calculate the sediment transport in the Sacramento River and the amount of sediment entrained in the diversion under each alternative.

The bedload analysis investigated the sediment transport capacity of the Sacramento River from Keswick to Colusa Weir. The USRDOM model divided the Sacramento River into 15 reaches based on fluvial geomorphology and hydrology. The USRDOM model daily flows were used to develop flow duration curves. Bedload transport was calculated using several available equations in the SRH-Meander model, with one selected that best described the available observational data. The transport of sediment particles that were larger than 2 millimeters was calculated in tons per year for each reach. Using this approach, the aggrading and degrading reaches could be identified, as well as changes in streambed composition predicted over the 82-year simulation period.

The effects on natural river meandering, bank erosion, and deposition in the Sacramento River channel between Red Bluff and Colusa was modeled using the SRH-Meander model. Inputs to the model included USRDOM model daily flows, streambank erodibility, and channel hydraulic characteristics.

7.3.3. Thresholds of Significance

The evaluation criteria for the impact analysis are based on professional judgment that considers current regulations, standards, and/or consultation with agencies, knowledge of the area, and the context and intensity of the environmental effects. For the purposes of this analysis, an impact on fluvial geomorphology would be considered significant if the Project would:

- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would result in substantial increase or decrease in on- or off-site erosion or siltation.

- Substantially alter natural river geomorphic processes (i.e., flow regime, sediment transport, and bank erosion) and existing river geomorphic characteristics (i.e., sinuosity, channel gradient, substrate composition, channel width and depth, and riparian vegetation).
- Substantially alter the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel in Funks and Stone Corral Creeks downstream of the Sites Reservoir.
- Substantially alter geomorphic processes upstream of the dam sites

7.4 Impact Analysis and Mitigation Measures

Impact FLV-1: Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would result in a substantial increase or decrease in on- or off-site erosion or siltation

No Project

The No Project Alternative represents the continuation of the existing conditions within the study area. Current drainage patterns, as well as existing routine operations and maintenance activities would continue, and there would be no alterations to existing drainage patterns relative to existing conditions.

Significance Determination

The No Project Alternative would not result in substantial alterations to existing drainage patterns, through either the alteration of a stream or river or the addition of impervious surfaces, that would result in a substantial increase or decrease in on- or off-site erosion or siltation because no new facilities would be constructed and operated. There would be no impact.

Alternatives 1, 2, and 3

Construction

Temporary soil disturbance during construction in level to gently sloping areas (e.g., for pipeline installations, TRR East [Alternatives 1 and 3 only], existing road modifications, and siphon replacements on Walker and Willow Creeks) is expected to result in little or no erosion and sedimentation because of the lack of runoff energy (i.e., gradient) to entrain, transport, and deposit sediment. Drainage manipulations in areas with moderate to steep slopes (i.e., locations of the main dams, saddle dams, TRR West [Alternative 2 only], transition manifold, Huffmaster Road realignment, and South Road [Alternative 2 only]) would be more prone to accelerated erosion and sedimentation. Soil eroded within the reservoir's watershed and inundation area would ultimately be deposited and retained in the inundation area. Soil eroded from areas outside the reservoir watershed and inundation area could reach outside receiving waters. BMPs would address potential increased erosion and siltation rates as a result of drainage pattern manipulation. The BMPs to Develop and Implement SWPPPs and Gain Coverage under Stormwater Construction General Permit would ensure that erosion and siltation rates would not be excessive. The BMPs would include erosion and sediment control measures and during-construction and post-construction runoff management measures. The erosion control measures would protect soils that have been exposed during excavation, filling, and stockpiling operations from eroding at rates greater than preconstruction conditions. The sediment control measures would capture sediment that was generated from exposed soils. The runoff management measures would reduce runoff rates and prevent concentrated runoff from causing scour, such as at culvert outfall points. System-wide, these measures would also ensure sediment would not be released into Sacramento River or the canals.

The Funks and TRR reservoirs and PGPs, administration and operation and maintenance buildings, Dunnigan Pipeline, Sacramento River discharge, and new roads, including the South Road (under Alternative 2 only) represent new facilities with the potential to alter existing drainage patterns and characteristics. The construction of these facilities would result in impervious surfaces or the facilities would be located in areas with characteristics that may lead to alterations of the existing drainage patterns (e.g., adjacent to existing receiving waterbodies, located in steeply sloped areas, or have moderately to highly erodible soils). Drainage infrastructure maintained by local landowners or local agencies would not be affected, and local surface runoff patterns would not be substantially altered because BMPs would identify design flows and incorporate measures to provide for drainage feature stability; incorporate appropriate relocation plans (for canals, ditches, wells, and other existing infrastructure); and incorporate other modifications to localized runoff amounts and/or patterns. Any necessary site features or procedures to remediate Project-induced drainage problems identified in the drainage evaluations would be installed before the Project was completed or as part of Alternatives 1, 2 or 3, depending on site-specific conditions.

<u>*Operation*</u>

Operation impacts were determined by evaluating suspended sediment increases and/or decreases. Decreases are important to identify for those aquatic organisms (e.g., delta smelt) that rely on suspended sediment and a certain level of turbidity within the study area. Suspended sediment transport modeling suggested that around 100,000–130,000 tons of sediment could be entrained annually by the TC Canal and GCID Main Canal diversions (as identified in the 2017 Draft EIR/EIS) compared to around 40,000–50,000 tons under existing conditions (see Table 2-6 of *Sediment Loads at Tehama-Colusa, Glenn-Colusa, and Delevan Diversions* in Appendix 7B). The entrained sediment load would represent less than or equal to 5% of Sacramento River sediment that otherwise could move downstream to the Delta, compared to around 3% under baseline conditions. Because water and sediment would both be diverted, the concentration of the sediment in the water would remain unchanged, so the turbidity of the water would be expected to remain the same as at the time the water was being diverted (i.e., principally in the winter/spring). The reduced (i.e., less than 5%) sediment load to the Delta under Alternatives 1, 2, and 3 may have relatively small effects on turbidity as a result of the reduction in sediment for resuspension at other times of the year because it is less than or equal to a 2% difference in the total suspended sediment output of the Sacramento River when compared to existing conditions. The importance of maintaining the existing sediment load of the Sacramento River is described in Chapter 11, *Aquatic Biological Resources*. Implementation of the sediment entrainment component of the Adaptive Management Plan developed for fish (described in detail in Appendix 2D) would inform whether adaptive management measures such as sediment reintroduction are warranted based on actual effects on turbidity under operation of Alternative 1, 2, or 3.

Most Project components (i.e., main dams and saddle dam construction, reservoir construction, Funks and TRR East and West and associated PGPs construction, Funks and TRR pipelines construction, TC Canal intake upgrades, CBD outlet upgrades, and GCID system upgrades) would create minimal new impervious surfaces with limited footprints. Under Alternatives 1 and 3, the amount of impervious surface would be approximately 260 acres. Alternative 2 would have slightly more impervious surfaces, approximately 325 acres. The South Road accounting for approximately 47 acres of impervious surfaces that are not included in Alternative 1 or 3. Project impervious surfaces would be designed to adequately drain water away under the BMP described for construction impacts.

Activities associated with the addition of two new pumps at RBPP would occur within its present footprint and would not result in changes to the footprint. There would be no new impervious footprints and thus a substantial reduction in the amount of natural soil surfaces available for infiltration of rainfall and runoff, thereby generating little, if any, additional runoff and associated erosion and siltation during storm events would not occur.

CEQA Significance Determination and Mitigation Measures

Construction of Alternative 1, 2, or 3 would not increase soil erosion and sedimentation rates as a result of alteration of existing drainage patterns. Where appropriate (i.e., depending on slope, soil type) the implementation of BMPs for erosion and sediment control would prevent increased soil erosion and sedimentation rates. Development and implementation of drainage evaluations for the Funks and TRR PGPs, administration and operation and maintenance buildings, Dunnigan Pipeline, Sacramento River discharge, road improvements, and new roads, including the South Road (under Alternative 2 only) would consider design flows, appropriate relocation plans, and other modifications to localized runoff amounts and/or patterns. This would reduce the potential for substantial alteration of existing drainage patterns, thereby not resulting in substantial erosion or siltation on- or off site as a result of construction.

Operation of Alternative 1, 2 or 3 would result in an increase in sediment entrainment. Implementation of the sediment entrainment component of the Adaptive Management Plan developed for fish would inform whether adaptive management measures such as sediment reintroduction are warranted based on estimated effects on turbidity. The addition of impervious surfaces would not substantially alter the existing drainage patterns of a site or area because of the limited area of impervious surfaces and the ability of the surrounding open area to infiltrate precipitation.

Construction and operation of the Project would not substantially alter the existing drainage pattern of the site or area in a manner which would result in a substantial increase or decrease in on- or off-site erosion or siltation. This impact is considered less than significant.

NEPA Conclusion

Construction and operation effects for Alternative 1, 2, or 3 would be the same as those described above for CEQA. The construction and operation of Alternative 1, 2, or 3 would not have an adverse effect on the existing drainage patterns or changes in on- or off-site erosion or sedimentation.

Impact FLV-2: Substantially alter natural river geomorphic processes (i.e., flow regime, sediment transport, and bank erosion) and existing river geomorphic characteristics (i.e., sinuosity, channel gradient, substrate composition, channel width and depth, and riparian vegetation).

No Project

The No Project Alternative represents the continuation of the existing conditions in the study area. Current channel morphology conditions, as well as existing routine operations and maintenance activities would continue, and there would be no change in the geomorphic regimes.

Significance Determination

The No Project Alternative would not result in substantial alterations to natural river geomorphic processes and existing river geomorphic characteristics because no new facilities would be constructed and operated. There would be no impact.

Alternatives 1 and 3

This section addresses potential impacts associated with alteration of natural river geomorphic processes and existing Sacramento River geomorphic characteristics as a result of operation of Alternatives 1 and 3 at RBPP and GCID Main Canal at Hamilton City. Construction impacts associated with Impact FLV-2 are discussed under Impact FLV-1.

Operation

Based on the USRDOM modeled flood flows, the differences (primarily reductions) in monthly average flow exceeded 10% of the time between the No Action Alternative and Alternatives 1 and 3 at the four Sacramento River locations shown in Table 7-3. These values show an increase of less than 1% to a decrease of less than 5% when compared to No Action Alternative, depending on the location (Table 7-4). These percentages are minor when considered in the context of the larger system.

Table 7-3. Percent Exceedance Values of USRDOM Modeled Monthly Average Flow for No Action Alternative and Alternatives 1, 2, and 3

Location	Location Relative to Project Elements	Capacity (cfs)	Month	Monthly Average Flow Exceeded 10% of the Time (cfs)				
				NAA	ALT 1A	ALT 1B	ALT 2	ALT 3
Sacramento River Flow at Bend Bridge	Between Shasta outflow and first diversion to Sites (Red Bluff)	98,000 (approx.)	Feb	40,506	40,526	40,461	40,509	40,461
Red Bluff Diversion	First diversion to Sites (serving TC Canal)	2,530	Jul	1,372	1,334	1,334	1,334	1,327
Sacramento River Flow below Red Bluff Diversion Dam	Between first diversion to Sites (Red Bluff) and second diversion to Sites (GCID)	260,000	Feb	41,165	39,155	39,091	41,146	39,091
Hamilton City Diversion	Second diversion to Sites (GCID)	3,000	Jun	2,696	2,689	2,678	2,670	2,663
Sacramento River near Wilkins Slough	Between second diversion to Sites (GCID) and Sites return (CBD)	30,000	Feb	26,450	26,211	26,473	26,424	26,401

Table notes:
The flood metrics are monthly average flows exceeded 10% of the time. This is the percent of time during which flows are relatively high and most of the geomorphic work would be performed on the system.
ALT = Alternative
CBD = Colusa Basin Drain
cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
NAA = No Action Alternative

Table 7-4. Flow and Percent Change between the No Action Alternative and Alternatives 1, 2, and 3

Location	Month	Monthly Average Flow Compared to No Action Alternative (cfs change/percent change)			
		ALT 1A	**ALT 1B**	**ALT 2**	**ALT 3**
At Bend Bridge	Feb	+20 <1% increase	+45 <1% increase	+3 <1% increase	+45 <1% increase
Red Bluff Diversion	July	-38 <3% decrease	-38 <3% decrease	-38 <3% decrease	-45 <3% decrease
Below Red Bluff Diversion Dam	Feb	-2,010 5% decrease	-2,075 5% decrease	-20 <1% decrease	-2,074 5% decrease
Hamilton City Diversion	June	-7 <1% decrease	-18 <1% decrease	-26 <1% decrease	-33 <1% decrease
Near Wilkins Slough	Feb	-239 <1% decrease	+24 <1% increase	-26 <1% decrease	-48 <1% decrease

Table notes:
cfs = cubic feet per second

As computed from Table 7-3 and as shown in Table 7-4, the average (system-wide) decrease in monthly average flow between the No Action Alternative and Alternative 1A is approximately 2%; the average (system-wide) decrease in monthly average flow between the No Action Alternative and Alternative 1B is also approximately 2%; and the average (system-wide) decrease in monthly average flow between the No Action Alternative and Alternative 3 is less than 2%. As shown in Table 7-4, the monthly average flow would increase in two instances, where both instances represent a change of less than 1%. The biggest changes (decreases) would occur in the Sacramento River below the RBDD. This is because that diversion point is considered the primary point of diversion (under each Alternative 1 or 3).

A fundamental principle of fluvial geomorphology suggests that a decrease in the amount of flow generally causes a corresponding decrease in flow velocity that typically induces sediment deposition. There is potential for the creation of localized areas of sediment deposition under Alternatives 1 and 3. The relative amount of potential deposition would be extremely limited because Alternative 1 or 3 diversions would only occur under higher flow regimes in the Sacramento River. These high flows would maintain sediment transport. As such, implementation of the diversion rates and amounts under Alternatives 1 and 3 would not measurably alter the natural river geomorphic processes and existing river geomorphic characteristics.

Finally, sediment removal at the RBPP and the GCID Main Canal intake, and the TC Canal intake would occur during the regularly scheduled maintenance period for these intakes using the same practices currently employed. Therefore, maintenance activities at these locations are expected to result in minimal (if any) alterations to Sacramento River geomorphic regimes as compared to the existing conditions.

Bedload sediment balance of a river is an important consideration for potential impacts with regards to sediment transport and other related geomorphic processes. The bedload analysis for the 1.8-MAF reservoir suggested no significant effects on the distribution of annual flows (differences of no more than a few percentages) and therefore no significant alteration of the bedload sediment balance in the Sacramento River. Under existing conditions, most reaches in the Sacramento River are not experiencing measurable aggradation or degradation, except for the reach in the vicinity of Moulton Weir, which is experiencing aggradation. The modeled bedload analysis do not significantly affect the aggradation that would continue in this reach.

The river meandering, bank erosion, and deposition modeling concluded that there were no significant differences between the channel alignments between the existing conditions and the modeled alternatives. Meander tendency varied between alternatives. For example, the reach from Stony Creek to Moulton Weir was modeled to experience the most amount of active channel migration, and the reach from Moulton Weir to Colusa Weir was modeled to experience less channel migration (under all modeled alternatives).

CEQA Significance Determination and Mitigation Measures

The average (system-wide) decrease in monthly average flow between the No Action Alternative and operations under Alternative 1 or 3 is approximately 2% and diversions would only occur under higher flow regimes in the Sacramento River. Operational impacts on the geomorphic regime (including natural river geomorphic processes such as sediment transport and bank erosion) and existing river geomorphic characteristics (e.g., sinuosity, channel gradient, substrate composition, channel width and depth, and riparian vegetation) of the greater Sacramento River system are expected to be minimal. The overall volume of water available and the pattern of water diversion in the Sacramento River (and therefore the canals, Yolo Bypass, and the Delta) would generally be similar to the amount and pattern of water diversion under existing conditions. Therefore, operation of Alternative 1 or 3 would not substantially alter natural river geomorphic processes and existing geomorphic characteristics for the Sacramento River and downstream of the river and impacts would be less than significant.

NEPA Conclusion

Operation effects for Alternative 1 or 3 would be the same as those described above for CEQA and would not substantially alter natural river geomorphic processes and existing river geomorphic characteristics. As such, implementation of the diversion rates and amounts under Alternative 1 or 3 would have no adverse effect.

Alternative 2

Operation

Operational impacts under Impact FLV-2 for Alternative 2 would be similar but lesser in magnitude to those as described above for Alternatives 1 and 3. Based on the USRDOM modeled flood flows, the differences (primarily reductions) in monthly average flow exceeded 10% of the time between the No Action Alternative and Alternative 2 at the four Sacramento River locations shown in Table 7-3 are relatively minor and range from an increase of less than 1% to a decrease of less than 3% when compared to No Action Alternative, depending on the location (Table 7-4).

As computed from Table 7-3 and as shown in Table 7-4, the average (system-wide) decrease in monthly average flow between the No Action Alternative and Alternative 2 is less than 1%. Monthly average flow would increase in one instance, with a change of less than 1%.

Similar to Alternatives 1 and 3, the relative amount of potential deposition under Alternative 2 would be extremely limited because diversions would only occur under higher flow regimes in the Sacramento River. As such, implementation of the diversion rates and amounts under Alternative 2 would not substantially alter the natural river geomorphic processes and existing river geomorphic characteristics.

Sediment removal activities at the RBPP and the GCID Main Canal intake and the results from the bedload and river meandering, bank erosion, and deposition modeling would be the same as described for Alternatives 1 and 3 and would not result in substantial alterations to natural river geomorphic processes and existing river geomorphic characteristics.

The point at which the Sacramento River discharge joins the Sacramento River possibly represents an area where historical meandering may have occurred (California Resources Agency 2003:6-4). However, the Sacramento River discharge location does not have setback levees in the vicinity and a review of available aerial imagery (from 1985 to the present) shows no evidence of historical meandering in this reach. Furthermore, a study by Northwest Hydraulic Consultants (2010:4) concludes that the river channel in this general area is closely bordered by levees with extensive revetment, and lateral channel evolution is limited. Therefore, operation of the Sacramento River discharge at this location would not substantially alter natural river geomorphic processes and existing river geomorphic characteristics.

Installation of the Sacramento River discharge would result in the removal of riparian vegetation along a short length of the west bank and replacement with rock slope protection. The operation of this facility would therefore occur in an area where vegetation was present prior to construction activities; however, the vegetation removal would not measurably affect overall stream function and geomorphic regime under Alternative 2 because there is already a significant amount of existing rock slope protection on the banks of the river in the vicinity of the discharge.

CEQA Significance Determination and Mitigation Measures

The average (system-wide) decrease in monthly average flow between the No Action Alternative and Alternative 2 is less than 1% and diversions would only occur under higher flow regimes in the Sacramento River. Similar to Alternatives 1 and 3, operation of Alternative 2 would not substantially alter natural river geomorphic processes and existing geomorphic characteristics and impacts would be less than significant.

NEPA Conclusion

Operation effects for Alternative 2 would be the same as those described above for CEQA and would not substantially alter natural river geomorphic processes and existing river geomorphic characteristics. As such, implementation of the diversion rates and amounts under Alternative 2 would have no adverse effect.

Impact FLV-3: Substantially alter the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel in Funks and Stone Corral Creeks downstream of Sites Reservoir.

No Project

The No Project Alternative represents the continuation of the existing conditions within the study area. Current channel morphologic elements, as well as existing routing operations and maintenance activities would continue, and there would be no change in geomorphic attributes.

Significance Determination

The No Project Alternative would not substantially alter the amount of instream woody material, boulder, shaded riverine aquatic habitat, or spawning gravel in Funks and Stone Corral Creeks downstream of Sites Reservoir because there would be no construction and operation of new facilities to affect instream characteristics. There would be no impact.

Alternatives 1, 2, and 3

Construction

Construction would result in minimal impacts on the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel in Funks and Stone Corral Creeks because the Sites Dam and Golden Gate Dam would have relatively limited footprints within these channels (approximately 2 acres of temporary impacts on Funks Creek and Stone Corral Creek). Aerial imagery of the areas where the dams would be constructed was reviewed and the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel appears to be minimal.

Erosion and sedimentation impacts from construction (which could have direct or indirect effects on the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel in Funks and Stone Corral Creeks) associated with Impact FLV-3 are discussed under Impact FLV-1.

Operation

The reaches of Funks and Stone Corral Creeks likely to be most modified by the two main dams are the reaches from below the dams to where these creeks have been modified by historical water management practices. On Stone Corral Creek, the reach of interest is from the downstream face of the Sites Dam to just above the GCID Main Canal (7.7 miles); on Funks Creek, it is from the downstream face of Golden Gate Dam to the upper end of Funks Reservoir (1.8 miles). While these reaches have been modified by cattle grazing and minor diversions, they still have available fish habitat and both native and nonnative fish have been observed in each drainage. They also both experience much of their natural hydrograph and fluvial geomorphic processes.

Stone Corral Creek would receive bypass flows from the reservoir from an outlet on the Sites Dam and Funks Creek would receive augmented flow from the Funks pipelines to its reaches immediately upstream of Funks Reservoir. Bypass flows would range from 0 to 100 cfs, with larger pulse flows to emulate natural flood conditions, and lower flows in the drier months (e.g., summer).

The augmentation of flow in each drainage would support the existing geomorphic functions of each channel (e.g., gravel, SRA). The following geomorphic field studies would be required once access is obtained and before final designs for Sites and Golden Gate Dams are completed, per the description in Chapter 2:

- Characterization of flows, including assessing the base flow during the summer months.
- Characterization of habitats available (e.g., spawning, rearing, foraging, and sheltering habitats) at varying flow levels. Characterization of habitats would help to inform what habitats are available at what flow regimes.
- Conducting a fluvial geomorphologic study to characterize bedload and flow levels necessary for substrate mobilization. Substrate mobilization is a key component of channel maintenance and supporting habitat diversity.
- Surface Water Ambient Monitoring Program (SWAMP) technical study (i.e., bioassessment) that focuses on relationships between physical habitat, water quality, and benthic macroinvertebrates. A SWAMP bioassessment would document the baseline conditions with individual metrics (i.e., scores) for physical habitat (the Index of Physical Integrity [IPI]) and benthic macroinvertebrates (the California Stream Conditions Index [CSCI]). The Project Operations Plan would ensure that the IPI and CSCI scores do not decrease relative to baseline conditions.

The Authority would use information from these field studies, along with currently available information, to prepare an Operations Plan for Funks and Stone Corral Creeks. The Operations Plan would identify the approach for releases, including release schedule and volumes, a monitoring plan, and an adaptive management plan to maintain fish in good condition consistent with California Fish and Game Code Section 5937. For example, characterizing the bedload would allow a determination as to whether the Operations Plan would require gravel augmentation. The information would be integrated to focus on aquatic species of concern in the lower portions of the two creeks to concentrate on habitat maintenance needs. ~~It is~~ expected flow releases from the Sites Reservoir to these creeks would mimic the natural discharge of the associated creeks, and that releases would be low during Dry and Critically Dry Water Years. The flow releases would be determined to support focus species. Conversely, flow releases would be higher during Above Normal Water Years.

Under Alternatives 1, 2 and 3, Sites Reservoir dams would be designed and constructed pursuant to criteria designed to prevent failure. The designs would incorporate multiple lines of defense or design redundancy as required to meet design standards reducing the potential for dam failure (Chapter 5, *Surface Water Resources* and Chapter 12, *Geology and Soils*). Furthermore, Alternatives 1, 2, and 3 would include the design and operation of facilities to meet criteria and requirements for emergency reservoir drawdown in the unlikely and rare event of an emergency. During an emergency release event, Saddle Dams 3 and 5 (Alternatives 1 and 3 only) and Saddle Dam 8B, the I/O Works, and Sites Dam would operate simultaneously to release water. In addition, the TRR East would have an emergency outlet into Funks Creek. In the unlikely and rare event of an emergency release, it is likely that overbank flooding (and localized deposition) would occur on the upper banks and floodplain surfaces of every channel receiving emergency release water, while the main channels would experience channel bed scour.

CEQA Significance Determination and Mitigation Measures

Construction impacts on the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel in Funks and Stone Corral Creeks would be less than significant as the Sites Dam and Golden Gate Dam would have relatively limited footprints within these channels. In addition, and as described under Impact FLV-1, the impact of increased soil erosion and sedimentation rates as a result of alteration of existing drainage patterns would be less than significant for Project elements under Alternative 1, 2, or 3 because erosion and sediment control measures would minimize and reduce erosion in accordance with the BMPs. These measures would also serve to ensure that there would be minimal to no substantial alteration of the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel in smaller creeks.

Operation of Alternative 1, 2, or 3, would provide bypass flows to Stone Corral and Funks Creeks. These flows would be refined through studies required under Project Commitments. These flows would support geomorphic processes in these channels by maintaining channel-forming flows and maintaining geomorphic processes (e.g. mobilization of bedload and erosion of stream banks) that support the fish assemblage and other aquatic species below the dams. The Sites Reservoir would meet design criteria to greatly reduce the potential of emergency releases that would likely create localized deposition and scour. Impacts would be less than significant.

NEPA Conclusion

Construction and operation effects for Alternative 1, 2, or 3 would be the same as those described above for CEQA and would not substantially alter the amount of instream woody material, boulders, shaded riverine aquatic habitat, or spawning gravel in Funks and Stone Corral Creeks downstream of the reservoir. Construction and operation would have no adverse effect.

Impact FLV-4: Substantially alter geomorphic processes upstream of the dam sites

No Project

The No Project Alternative represents the continuation of the existing conditions within the study area. Antelope Valley and the ephemeral drainages within and extending upslope of the valley would remain intact and not be inundated. There would be no change in geomorphic attributes relative to existing conditions.

Significance Determination

The No Project Alternative would not result in a substantial alteration in the amount of ephemeral stream habitat and associated geomorphic processes upstream of Sites Reservoir. There would be no inundation within the existing Antelope Valley drainage network and no changes would occur to the existing geomorphic attributes because no new facilities would be constructed and operated. There would be no impact.

Alternatives 1, 2, and 3

This section addresses potential impacts associated with alteration of existing ephemeral stream habitat and associated geomorphic processes in the smaller creeks within and upslope of Antelope Valley.

Construction and Operation

Under Alternative 1 or 3 approximately 24.3 miles[3] of primarily marginal ephemeral channel habitat that experiences sediment transport, scour, and deposition based on the volume and duration of precipitation would be inundated. Under Alternative 2 approximately 24.1 miles[4] of primarily marginal ephemeral channel habitat would be inundated. This habitat is marginal because the streams are ephemeral, have abundant algae at low flow, have minimal and sporadic shrub or tree riparian vegetation, and have been degraded by cattle trampling. The current geomorphic processes would cease to function (e.g., sediment transport, scour, and deposition) as riverine geomorphic processes would be replaced with lacustrine/reservoir processes (e.g., limited transport and movement and sediment migrating to depressions within the inundation area). Over time, it is likely the channel segments in the Antelope Valley that would not be inundated would adjust to a new base level, albeit a temporally fluctuating one (i.e., the water surface of the Sites Reservoir) via adjustments to their channel beds upstream of the new water surface. Deposition of materials in short stretches of the downstream reaches of these channels would increase due to changes in base level. These channels appear to be relatively static (non-dynamic) fluvial systems. Impacts would be expected to be relatively small, although the magnitude of such changes is uncertain and difficult to quantify or qualify given the lack of predictive capability regarding fluvial geomorphic processes once the reservoir was inundated.

Habitats associated with these ephemeral channels are described in Chapter 9, *Vegetation and Wetland Resources*; Chapter 10, *Wildlife Resources*; and Chapter 11, *Aquatic Biological Resources*.

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[3] This number only includes the named streams within the Antelope Valley. There are also various unnamed tributaries to the named channels.

[4] This number only includes the named streams within the Antelope Valley. There are also various unnamed tributaries to the named channels.

CEQA Significance Determination and Mitigation Measures

The current riverine geomorphic processes within the inundated area would be replaced with lacustrine/reservoir processes. The non-inundated portions of the ephemeral channel network would adjust to a new geomorphic equilibrium, although the magnitude of such changes is uncertain and difficult to quantify or qualify. No significant erosion or deposition is expected under the operation of the Sites Reservoir and substantial alteration of geomorphic processes upstream of the dam sites is not expected. Construction and operation impacts would be less than significant.

NEPA Conclusion

Construction and operation effects would be the same as those described above for CEQA. Sites Reservoir construction and operation would have no adverse effect on the alteration of geomorphic processes upstream of the main dam sites.

7.5 References

7.5.1. Printed References

AECOM. 2020. *Geology and Seismicity Technical Memorandum*. August 18. Sites Program Management Team.

Brown, C.J. 2000. *North of the Delta Offstream Storage Investigation, Progress Report, Appendix D: Fish Survey Summary*. September. Prepared for the California Department of Fish and Game with the assistance of Waiman Yip, California Department of Water Resources.

California Resources Agency. 2003. SB 1086, Sacramento River Conservation Area Forum Handbook. September. Prepared for The Resources Agency, State of California by the Sacramento River Advisory Council under Senate Bill 1086, authored by Senator Jim Nielsen.

H. T. Harvey & Associates, G. Mathias Kondolf, Geomorph, and Blankinship & Associates. 2008. *Colusa Basin Watershed Assessment*. December. Prepared for Colusa County Resource Conservation District.

Northwest Hydraulic Consultants. 2010. *Comprehensive Geomorphic and Sedimentation Analyses of Lower Sacramento River for Flood Management, Erosion Mitigation and Habitat Enhancement Design*. Proceedings from the 2nd Joint Federal Interagency Conference, June 27–July 1, 2010, Las Vegas, NV.

Soil Survey Staff. 2020. Web Soil Survey. Natural Resources Conservation Service, United States Department of Agriculture. Available:

https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. Accessed: October 21, 2020.

Water Engineering & Technology. 1990. *Geomorphic Analysis and Bank Protection Alternatives Report for Sacramento River (RM 78–194) and Feather River (RM 0–28)*. May. Fort Collins, CO. Prepared for U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA.