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, Yolo Bypass, Sutter Bypass, and the Delta. Human-made drainage canals (i.e., TC Canal, GCID Main Canal, and CBD) are also included in the study area. Figures 1-1, 1-2, and 1-3 identify these various locations.

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. There would be no construction geomorphic effects within these areas and, based on the various modeling results available for the Project, operational geomorphic effects associated with the Project would have minimal or no impact on the Feather River and American River and associated flood storage facilities. As described in Chapter 2, the Project would not affect or result in changes in the operation of the Central Valley Project, Trinity River Division facilities (including Clear Creek) and thus Trinity River resources are not discussed or analyzed further in this chapter.

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

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
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
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 no impact
LTS = CEQA less-than-significant impact
NE = NEPA no effect or no 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
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			

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
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 no impact
LTS = CEQA less-than-significant impact
NE = NEPA no effect or no adverse effect

7.2 Environmental Setting

This section presents an overview of 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 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. For additional information regarding geology refer to Chapter 12, *Geology and Soils*.

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
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	–	–

Creek Name	Location, Flow Direction, and Approximate Length	Water Regime	Planform	Primary Habitat Unit[a]	Channel Substrate[a]
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 associated with the Project are Walker Creek (Figure 2-8), Willow Creek (Figure 2-8), and Bird Creek (Figure 2-2).

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 and north of Willows in Glenn County. 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 I-5.

Bird Creek exits the Coast Range foothills and drains in an easterly direction into the CBD, approximately 2 to 3 miles south of Dunnigan in Yolo County. 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 study area. 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 (i.e., downstream of Red Bluff). 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). Flood basins, sedimentation, and regional geomorphic descriptions for the Sacramento River are provided below.

7.2.3.1. Flood Basins of the Sacramento River

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 narrow 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.

7.2.3.2. 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).

7.2.3.3. 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 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 (Alternative 2). 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 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 via the Knights Landing Outfall Gates and 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

[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.

its surrounding levees, its width averages approximately 575 feet. The Knights Landing Ridge Cut is described in more detail in Section 5.2.1.2, *Conveyance Systems*.

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. Section 5.2.1.5, *Yolo Bypass*, and Appendix 7A have additional hydrologic and geomorphic information about the Yolo Bypass.

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 upstream, on-river 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 fluvial geomorphology is both quantitative (using and interpreting modeling results) and qualitative (using information about local fluvial geomorphology to describe 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.

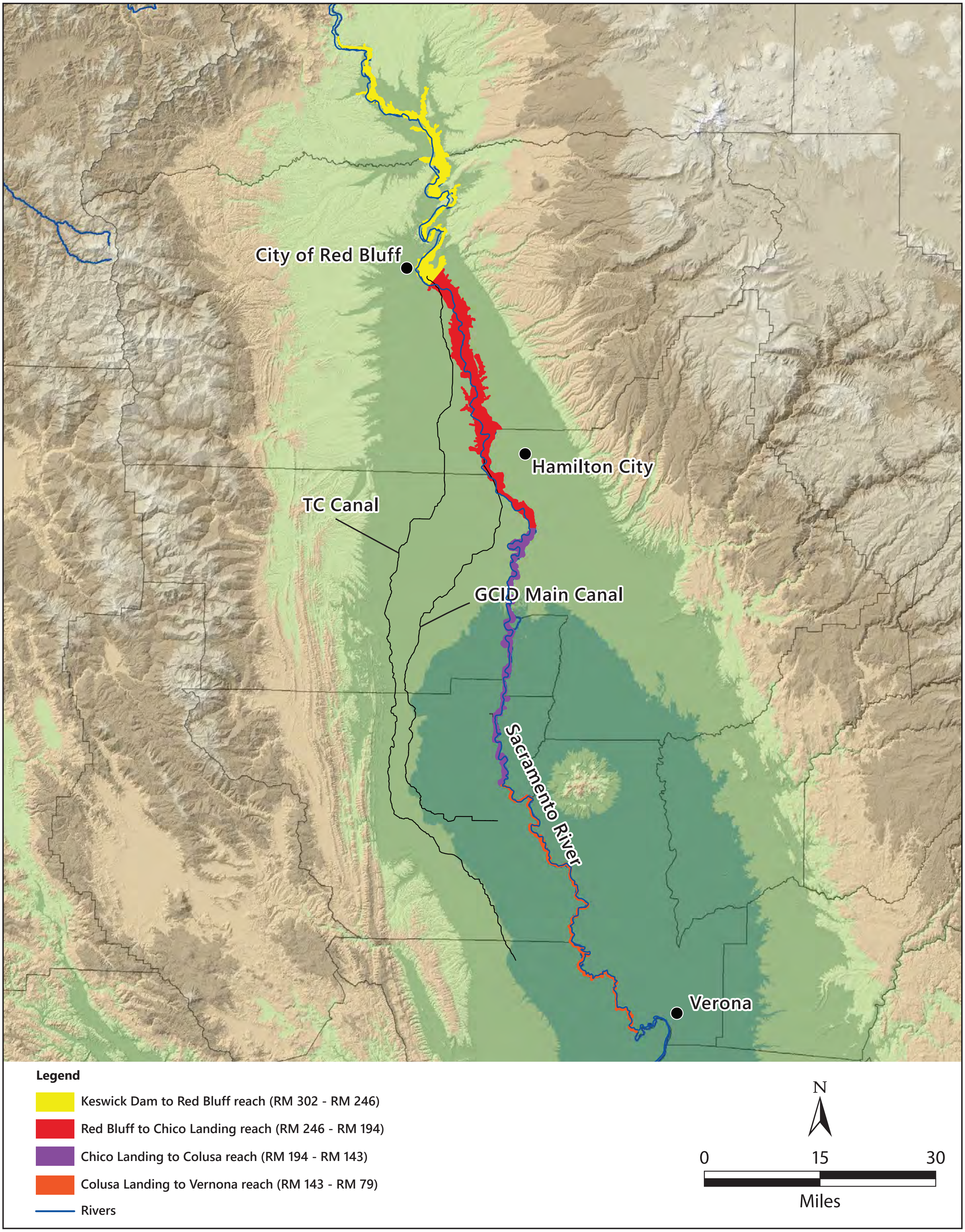

Figure 7-1
Sacramento River Reaches

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, Management Plans, and Technical Studies*, are incorporated into the analysis of potential construction impacts on fluvial geomorphology. These BMPs will minimize alterations to existing drainage infrastructure and patterns and are summarized below.

- BMP-14, Obtainment of Permit Coverage and Compliance with Requirements of Central Valley Regional Water Quality Control Board Order R5-2016-0076-01 (National Pollutant Discharge Elimination System No. CAG995002 for Limited Threat Discharges to Surface Water) and State Water Resource Control Board Order 2003-0003-003-DWQ (Statewide General Waste Discharge Requirements For Discharges To Land With A Low Threat To Water Quality), requires coverage under and compliance with waste discharge requirements.
- BMP-12, Development and Implementation of Stormwater Pollution Prevention Plan(s) (SWPPP) and Obtainment of Coverage under Stormwater Construction General Permit (Stormwater and Non-stormwater), requires implementation of erosion and sediment control measures, waste management measures, non-stormwater management measures, and postconstruction stormwater management measures to prevent the movement of sediment outside construction zones.
- BMP-15, Performance of Site-Specific Drainage Evaluations, Design, and Implementation, requires evaluation of local drainage features during final Project design and incorporation of necessary design features (e.g., low impact development practices, bioswales, infiltration basins) to result in equivalent functioning of existing drainage system.

7.3.2. Operation

Operational impacts of Alternatives 1, 2, and 3 were evaluated quantitatively using modeled results and qualitatively using available mapping and existing studies of locations in the study area. The following models were used and are described below: CALSIM II, Upper Sacramento River Daily Operations Model (USRDOM), suspended sediment transport model, bedload transport model, and SRH-Meander.

The USRDOM model 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 period of record used in the USRDOM model is from Water Year 1922 through Water Year

2003. 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. These values are very close to the 2-year flood event at each station. The USRDOM model description and additional 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*

Geomorphic processes are spatially and temporally variable throughout a river system. As such, 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 location on the Sacramento River. The previous modeled results are valid for the geographic scale of the whole of the upper Sacramento River at which impacts on fluvial geomorphology are being considered in this document 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 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. The equation used by Wilcock and Crowe (2003), which is considered to be a “consistent” and simple equation, was selected because it 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 reaches (i.e., areas undergoing deposition) and degrading reaches (i.e., areas undergoing scour and erosion) could be identified, as well as changes in streambed composition predicted over the 82-year simulation period.

SRH-Meander was used to predict the channel alignments in 2030 based on 2009 channel alignment and modeling 20 years of hydrology from October 1, 2010, to September 30, 2030, using USRDOM flows. The effects on natural river meandering, bank erosion, and deposition in the Sacramento River channel between Red Bluff and Colusa was modeled using the 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 study 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 additional alterations to existing drainage patterns relative to existing conditions. Present-day geomorphic processes (which contribute to the dynamic nature of fluvial environments) would continue to operate as normal, with influences from both independent basin controls (geology, climate, vegetation, physiography, and anthropogenic influences) and independent channel controls (valley slope, discharge, sediment load, and streambank characteristics).

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/no effect.

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, siphon replacements on Walker and Willow Creeks, and the Bird Creek crossing for the Dunnigan Pipeline) 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 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.

The implementation of BMP-12 by the Authority or its contractor(s) will avoid or minimize the potential for increased erosion and siltation rates resulting from construction activities. The Authority or its contractor(s) will use multiple erosion control techniques such as silt fencing, weed-free straw bale barriers, fiber rolls, storm drain inlet protection, hydraulic mulch, and stabilized construction entrances during the construction phase, all of which will prevent or minimize erosion and sedimentation in areas disturbed during construction. The Authority or its contractor(s) will be responsible for implementing multiple erosion control measures that will protect disturbed surfaces under wet conditions (e.g., winter, spring); prevent runoff from reaching areas prone to erosion; and retain native vegetation to stabilize soils, uptake precipitation and surface runoff, and reduce erosion. The Authority or its contractor(s) will reduce erosion and siltation rates during construction by capturing eroded sediment on site (e.g., in basins or traps); installing barriers to keep construction-related sediment (e.g., soil, tunnel muck) from entering adjacent onsite or offsite aquatic features, including drainages; and storing piles of excavated materials away from drainages and installing barriers along the piles' downslope perimeters to prevent erosion from rain events.

The TRRs and Funks Reservoir, PGPs, administration and operation and maintenance buildings, Dunnigan Pipeline, 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).

The implementation of BMP-15 by the Authority or its contractor(s) will include consideration of design features to require equivalent functioning of existing drainage system(s) during and after construction to reduce disruption to local drainage systems. The postconstruction rate, volume, and duration of runoff will not substantially exceed the predevelopment rates and the predevelopment hydrologic conditions will be replicated through site design, drainage configuration, and the site-specific application of other appropriate drainage/runoff management practices to the maximum extent that is technically feasible. The measures in BMP-15 will prevent substantial erosion and sedimentation beyond which is generally experienced by the existing drainage systems. BMP-15 is consistent with local requirements for new development (e.g., County of Colusa requirement to demonstrate that Project implementation would not result in increases in the peak flow runoff to adjacent lands or drainage facilities).

Installation of the Sacramento River discharge (Alternative 2) would involve construction activities within the margins of the Sacramento River (i.e., in-water work) and would result in the removal of riparian vegetation (approximately 0.10 acres) along a short length of the west bank and replacement with a concrete apron. A concrete apron extending into the Sacramento River would have a minimal footprint (approximately 0.25 acres). BMP-14 requires that the discharge of water diverted from streams and canals and removed during dewatering activities be done in compliance with the requirements of the Central Valley Regional Water Quality Control Board (Central Valley RWQCB) Order 5-2016-0076. Water will be pumped into Baker tanks, or approved equivalent, with either a filter or gel coagulant system or other containment to remove sediment as required and as necessary (remaining water will be discharged to a designated receiving water body or via land application, in accordance with the requirements of Central Valley RWQCB Order 5-2016-0076 and State Water Resource Control Board Order 2003-0003-003-DWQ). Specific to the discharge structure, silt curtains will be used when installing coffer dam sheet piles for construction of the Sacramento River discharge to minimize turbidity effects in the Sacramento River. Water pumped from behind the coffer dam (i.e., on the landward side) will be discharged through a silt sock to the area between the coffer dam and the silt curtains to minimize turbidity effects in the river channel. These measures will collectively reduce the potential for a substantial increase in on- or offsite erosion or siltation at the Sacramento River discharge location.

Operation

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 suggests that around 100,000–130,000tons 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 during Project diversions (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 Sediment Technical Studies Plan and Adaptive Management for Sacramento River (Section 2D.5) will 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 or West and associated PGP 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 total amount of impervious surface over the footprint would be approximately 260 acres. Alternative 2 would have slightly more impervious surfaces at approximately 325 total acres; the South Road accounts for approximately 47 acres of impervious surfaces that are not included in Alternative 1 or 3. As described above under the construction impacts, various measures to evaluate pre- and post-Project drainage needs and design features to ensure local drainage infrastructure (e.g., ditches, pipes, culverts, wells) would not be disrupted, and to remediate any Project-related alteration in runoff patterns that would increase the potential for localized erosion and sedimentation are included as part of the Project.

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 surfaces at this location. Thus, 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 significantly 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 BMP-12 will prevent increased soil erosion and sedimentation rates. Development and implementation of drainage evaluations in BMP-15 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) will consider design flows, appropriate relocation plans, and other modifications to localized runoff amounts and/or patterns. BMP-15 will 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 described in Section 2D.5 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 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 of Project alternatives would not significantly increase soil erosion and sedimentation rates as a result of alteration of existing drainage patterns as compared to the No Project Alternative. BMP-12 will prevent increased soil erosion and sedimentation rates, and BMP-15 will reduce the potential for substantial alteration of existing drainage patterns. The operation of the Project alternatives would not substantially alter the existing drainage patterns of a site or area as compared to the No Project Alternative because of the limited area of impervious surfaces and the ability of the surrounding open area to infiltrate precipitation. The construction and operation of Alternative 1, 2, or 3 would not have an adverse effect on the existing drainage patterns or changes in onsite or offsite 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. Present-day geomorphic processes (which contribute to the dynamic nature of fluvial environments) would continue to operate as normal, with influences from both independent basin controls (geology, climate, vegetation, physiography, and anthropogenic influences) and independent channel controls (valley slope, discharge, sediment load, and streambank characteristics).

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/no effect.

Alternatives 1 and 3

This section addresses potential impacts associated with alteration of natural river geomorphic processes and existing Sacramento River, Yolo Bypass, and Delta 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).

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.
Alternatives 1A and 1B are both being considered under Alternative 1 as described in Chapter 3.
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:
Alternatives 1A and 1B are both being considered under Alternative 1 as described in Chapter 3.
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.

The bedload sediment balance of the Sacramento River is a primary consideration for evaluating potential Project impacts associated with sediment transport and other related geomorphic processes. The previously conducted bedload analysis for the Sacramento River suggested no significant effects on the distribution of annual flow duration curves (i.e., differences of no more than a few percentages) and therefore no significant alteration of the bedload sediment balance in the river. Bedload transport capacity upstream of the diversion at RBPP was modeled to increase from existing conditions by 2% to 6% because the high flows through these reaches are increased slightly; from the diversion at RBPP to the diversion at Hamilton City, the bedload transport capacity was modeled to decrease by 2% to 4% from existing conditions due to the increased diversion rates at RBPP during high flow periods; from the GCID Main Canal to the previously included Delevan Intake location, the bedload transport capacity was modeled to decrease from existing conditions by 2% to 6%; and downstream of the Delevan Intake location, the bedload transport capacity was modeled to decrease by 4% to 6% (for two of the modeled alternatives) and 10% to 12% (for one of the modeled alternatives). 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 indicated no significant effect from the aggradation that would continue in this reach. The previous bedload modeling effort suggested minimal changes in the sediment transport regime compared to existing conditions. These changes are expected to be smaller in magnitude under Alternatives 1 and 3, as the diversions from the

Sacramento River would fill a smaller reservoir than was previously modeled. Furthermore, Alternatives 1 and 3 would use two existing diversions (i.e., RBPP and Hamilton City). These alternatives would not involve a Delevan Intake and therefore the previously modeled decrease in bedload transport capacity downstream of the former Delevan Intake location would be reduced or eliminated.

With respect to the SRH-Meander model, the authors of the modeling effort suggested that the tendency for meander and the difference between Alternatives 1 and 3 is not considered significant considering the inherent variability in the system. The river meandering, bank erosion, and deposition modeling concluded that there were no significant differences between the channel alignments between existing conditions and the modeled alternatives. Meander tendency (the degree to which the river would move laterally) was modeled to be greatest in the reach from Stony Creek to Moulton Weir.

Yolo Bypass, Sutter Bypass, and Delta

Based on the CALSIM II modeled flows, Sites Reservoir releases to the Yolo Bypass would be greater during Wet Water Years than in Critically Dry Water Years (Table 5-20), with releases reaching 350–440 cubic feet per second (cfs) during August and September of Wet Water Years. Percent change in total Yolo Bypass flows is expected to be large during August–October because existing Yolo Bypass flows are generally low during these months (Table 5-21). These increases have the potential to create some localized scour during the drier months. However, because 4,000 cfs is roughly the flow at which floodplain inundation occurs in the Yolo Bypass (Takata et al. 2017), any scouring (and associated downstream deposition) that occurs would be spatially variable (i.e., dependent on local topography and hydraulics) and cause minimal disruption overall to the channel(s) in the bypass. Furthermore, the anticipated releases of 350–440 cfs are well below the maximum amount of water that the Yolo Bypass has historically received in August and September (636 and 750 cfs, respectively; Table 5-8).

Daily-downscaled CALSIM II modeling suggests that operations under Alternatives 1 and 3 may reduce Yolo Bypass inundation from January through June by approximately one day across most water year types (Table 11-11) and small percent reductions (less than 5% for both Critically Dry and Wet Water Years) in the Yolo Bypass flows are expected during the rainy season as a result of the diversions to Sites Reservoir storage (Table 5-21). The flows into the Yolo Bypass during operation of Alternative 1 or 3 would be within historical values typically received by the bypass and would not significantly alter the existing geomorphic processes.

In the Sutter Bypass, both the increases and decreases in flow during Alternative 1 or 3 for all months are minimal to non-existent compared to existing conditions (Table 11M-2 in Appendix 11M) based on the anticipated releases under Alternative 1 or 3. Anticipated geomorphic change in the Sutter Bypass a result of Alternative 1 or 3 is therefore minimal to non-existent.

The combined effects of Sites Reservoir diversions, Sites Reservoir releases to the Sacramento River and the Yolo Bypass, and small operational changes for Shasta Lake, Lake Oroville, and Folsom Lake would produce small percentage reductions in Delta outflow during the wetter months. During drier months, these combined effects would allow increases in Delta outflow, particularly during Critically Dry Water Years. Increases in exports during the summer of Critically Dry Water Years could also occur (Table 5-27 and 5-28).

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 would generally be similar to the amount and pattern of water diversion under existing conditions. In the Yolo Bypass, any scouring (and associated downstream deposition) that occurs would be limited to the low-flow channel and cause minimal disruption to the overall channel within the bypass during the driest months. The proposed flows into the bypasses would be within historical values typically received by the bypass and would not significantly alter the existing geomorphic processes during the wet months. Therefore, operation of Alternative 1 or 3 would not substantially alter natural river geomorphic processes and existing geomorphic characteristics for the Sacramento River, Yolo Bypass, Sutter Bypass, and Delta 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. 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. The overall volume of water available and the pattern of water diversion in the Sacramento River would generally be similar to the No Project Alternative. The proposed flows into the bypasses would be within historical values typically received by the bypass and would not significantly alter the existing geomorphic processes during the wet months. 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 listed in Table 7-3 are relatively minor. The differences 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.

Similar to Alternatives 1 and 3, and as described above, the flows to the Yolo Bypass during operation of Alternative 2, would be within historical values typically received by the bypass and would not significantly alter the existing geomorphic processes within the bypass.

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 (approximately 0.10 acres) 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. The apron that would extend into the Sacramento River would have a minimal footprint (approximately 0.25 acres) and not affect the local geomorphic processes of the river.

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. 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. Alternative 2 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. Present-day geomorphic processes (which contribute to the dynamic nature of fluvial environments) would continue to operate as normal, with influences from both independent basin controls (geology, climate, vegetation, physiography, and anthropogenic influences) and independent channel controls (valley slope, discharge, sediment load, and streambank characteristics).

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/no effect.

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 and their respective bypass discharge locations would have relatively limited footprints within these channels (approximately 2 acres of temporary impacts on Funks Creek and Stone Corral Creek). Aerial imagery (from 1995 through 2018) of the areas where the dams and discharge points 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) (Figure 1-3). 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 and provide sediment that ultimately flows into the CBD during rain events.

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. The following geomorphic field studies (described in Section 2D.4) 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.

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 (Section 2D.4). 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 that 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. 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 (BMP-1). The designs would incorporate multiple lines of defense or design redundancy as required to meet design standards reducing the potential for dam failure[3] (discussed in Chapters 5 and 12). 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, if constructed) and Saddle Dam 8B, the I/O Works, and Sites Dam would operate simultaneously to release water. In addition, the TRR East (Alternatives 1 and 3) 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 for BMP-12 will minimize and reduce erosion. 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 described in Section 2D.4. 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. Construction and operation of the Project alternatives 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 as compared to the No Project Alternative. Construction of the Project alternatives would have limited footprints in Funks and Stone Corral Creeks, and BMP-12 will minimize and reduce

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[3] The known faults, geologic structures, and seismic activity of the area would be considered in the final design of the main dams, saddle dams, and saddle dikes and would be designed to conform with all applicable design criteria. The main dams, saddle dams, and saddle dikes would also be designed to accommodate the maximum predicted fault offset (Chapter 12, *Geology and Soils*, Table 12-6). The dams would be designed to ensure the dam embankment is not impaired by extensive cracking, crest settlement, or excessive deformation in critical zones, and the design would limit seismic deformation to 5 feet. Furthermore, monitoring equipment and tools, including strong motion seismic detectors, piezometers, settlement points, and seepage weirs, would be permanently installed at each dam site, and strong motion seismic detectors would be installed at center crests, abutments, and toes of Golden Gate Dam and Sites Dam.

erosion. Operation of the Project alternatives would provide bypass flows to Stone Corral and Funks Creeks that would support geomorphic processes in these channels by maintaining channel-forming flows and maintaining geomorphic processes. 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/no effect.

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[4] 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[5] 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, the channel segments in the Antelope Valley not inundated would generally adjust to a new base level that temporally fluctuates more frequently (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

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

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

changes in base level. Based on the review of aerial imagery, these channels appear to be relatively static (non-dynamic) fluvial systems; however, due to the extensive cattle grazing the creeks are likely experiencing channel degradation and bank retreat. Impacts would be expected to be relatively small (i.e., localized delta formation), and the processes within the channels upstream of the immediate inflows to the reservoir (i.e., the inundation lines) would most likely continue as the Project would not affect those areas.

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

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, possibly establishing some local areas of sediment deposition near the inundation areas. Besides these localized areas, no significant erosion or deposition is expected under the operation of Alternatives 1, 2 or 3 would occur 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. Construction and operation of Alternatives 1, 2, and 3 would replace the current riverine geomorphic processes under the No Project Alternative within the inundated area with lacustrine/reservoir processes. The non-inundated portions of the ephemeral channel network would adjust to a new geomorphic equilibrium, and no significant erosion or deposition is expected under the operation of the Project alternatives as compared to the No Project Alternative. 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

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