Chapter 11
Geology and Soils

This chapter describes the affected environment for geology and soils, as well as potential environmental consequences and associated mitigation measures, as they pertain to implementing the alternatives. This chapter presents information on the primary study area (area of project features, the Temperance Flat Reservoir Area, and Millerton Lake below RM 274). It also discusses the extended study area (San Joaquin River from Friant Dam to the Merced River, the San Joaquin River from the Merced River to the Delta, the Delta, and the CVP and SWP water service areas).

Affected Environment

This section describes the affected environment related to geology, geologic hazards, erosion and sedimentation, geomorphology, mineral resources, soils, and salts.

Where appropriate, geology and soils characteristics are described in a regional context, including geologic provinces, physiographic regions, or other large-scale areas, with some area-specific geologic maps and descriptions of specific soil associations.

Geology

This section describes the geology of the primary and extended study areas.

Primary Study Area

A description of the surficial geologic units encountered in the primary study area is presented in Table 11-1. Geologic maps of the primary study area and the area of project features are presented in Figure 11-1 and Figure 11-2, respectively.

Table 11-1. Description of Surficial Geologic Units of the Primary Study Area

Geologic Map of Millerton Lake Quadrangle, West-Central Sierra Nevada, California[1]

Formation Abbreviation	Surficial Deposits	General Features
Kbl	Tonalite of Blue Canyon - blocky hornblende facies	Plutonic rocks characterized by undeformed blocky hornblende prisms as long as 1 cm and by biotite books as much as 5 mm across. Surface geology would potentially be intercepted by area project features, including the 500-foot power transmission alignment and haul roads under Option C.
Pzv	Metamorphosed Volcanic and Volcanogenic Rocks	Metamorphosed volcanic and volcanogenic rocks characterized as generally strongly foliated and lineated with amphibolite, often massive. Surface geology would be intercepted by area project features, including access roads cut and fill and the powerhouse footprint.
Pzs	Metasedimentary Rocks - quartz-biotite schist	Metasedimentary rocks are strongly foliated and lineated with minor folds that are isoclinal, and which axes plunge steeply. These rocks include thin layers of quartzite.
Kblb	Tonalite of Blue Canyon - Biotite-rich facies	Biotite-rich facies of the tonalite of Blue Canyon in the northeastern part of the primary study area may contain 5 to 12 percent poikilitic K-feldspar crystals 1 to 3 cm across. The portion of the biotite-rich facies in the south-central portion of the quadrangle that overlaps with the primary study area may contain subhedral biotite books and quartz crystals as large as 1 cm across.
KJgb	Gabbro	Gabbro is primarily plagioclase-hornblende that exhibits a range of textures and locally contains minor olivine and/or augite. Surface geology would be intercepted by area project features, including access and haul roads, cut and fill, potential batch plant (Options A, B, and C), diversion tunnel, and selective level intake structure (Alternative Plan 4).
Qdf	Debris Flow	Debris flow deposits may be a few meters thick and are typically composed of angular trachyandesite blocks, from erosional undercutting of margins of Kennedy Table, and rounded metavolcanic cobbles in a sandy matrix. Surface geology could be intercepted by potential area project features, including access roads under Option C.
Kgd	Biotite Granodiorite	Millerton Ridge pluton is located in the south-central part of the quadrangle and would overlap with area project, features including the potential aggregate quarry (Option A) and batch plant (Options A, B, and C), a portion of the proposed Temperance Flat RM 274 Dam site, and staging area. Millerton Ridge is a leucogranodiorite and contains garnet (0.1 – 2 mm across) along the western edge.
Pzvh	Metamorphosed Volcanic and Volcanogenic Rocks - quartz-hornblende-plagioclase schist	Metamorphosed volcanic and volcanogenic rocks characterized as generally strongly foliated and lineated with amphibolite, often massive. Surface geology would potentially be intercepted by area project features, including the 500-foot power transmission alignment and potential batch plant (Options B and C).
Pzva	Metamorphosed Volcanic and Volcanogenic Rocks - plagioclase-diopside-hornblende amphibolite	Metamorphosed volcanic and volcanogenic rocks characterized as generally strongly foliated and lineated with amphibolite, often massive. Surface geology would potentially be intercepted by area project features, including a potential aggregate quarry (Option C).

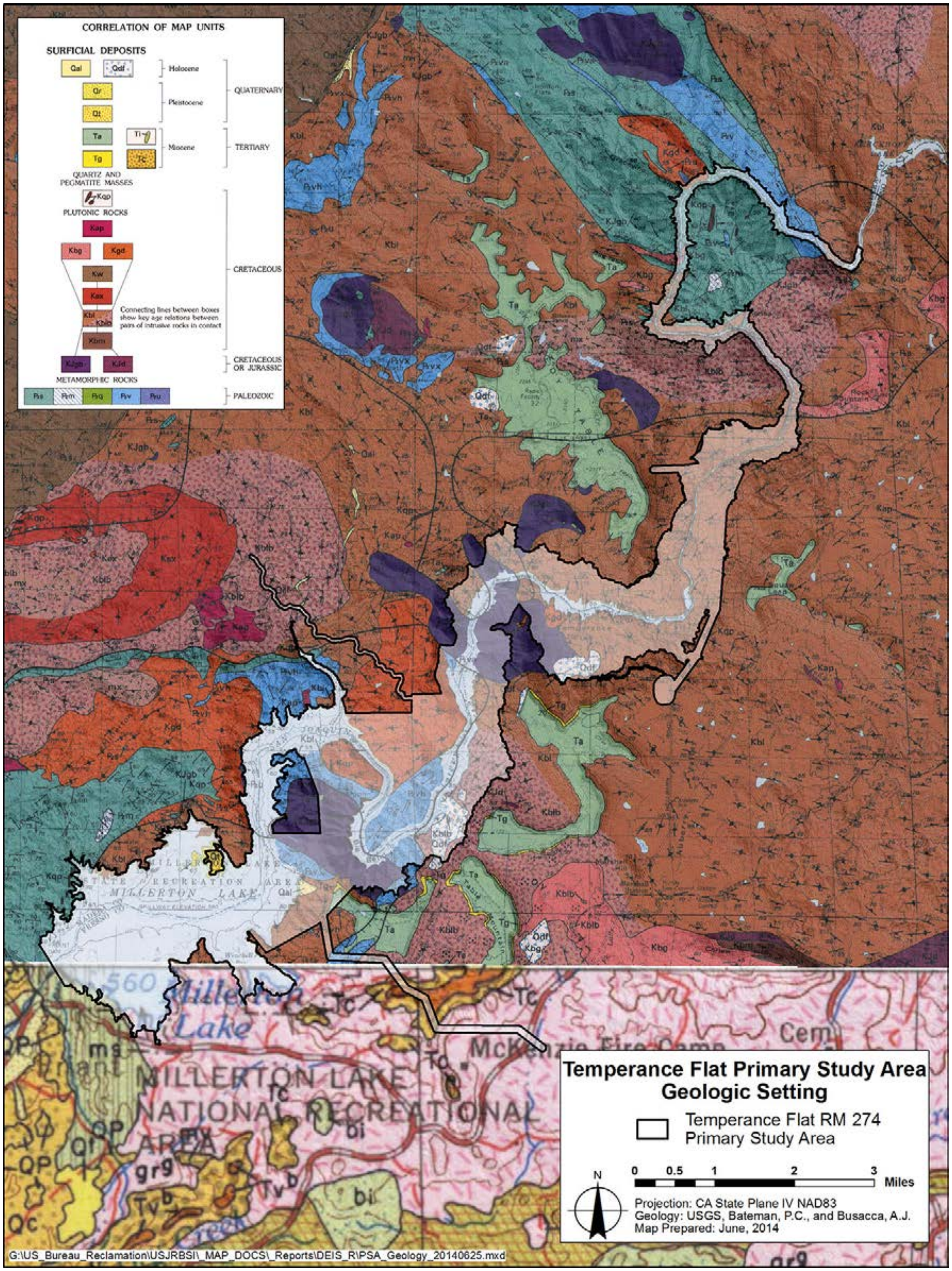
Table 11-1. Description of Surficial Geologic Units of the Primary Study Area (contd.)

Geologic Map of Millerton Lake Quadrangle, West-Central Sierra Nevada, California[1] (contd.)		
Formation Abbreviation	**Surficial Deposits**	**General Features**
Pzu	Metasedimentary and Metavolcanic Rocks, Undifferentiated	Metasedimentary and metavolcanic rocks, undifferentiated
Qal	Alluvium	Stream and gravel alluvium

Geologic Map of California, Fresno Sheet[2], Scale 1:250,000		
Formation Abbreviation	**Surficial Deposits**	**General Features**
Tvb	Tertiary volcanic	Pyroclastic rocks
Tc	Tertiary nonmarine	Tertiary nonmarine
grg	Mesozoic granitic rocks	Granodiorite

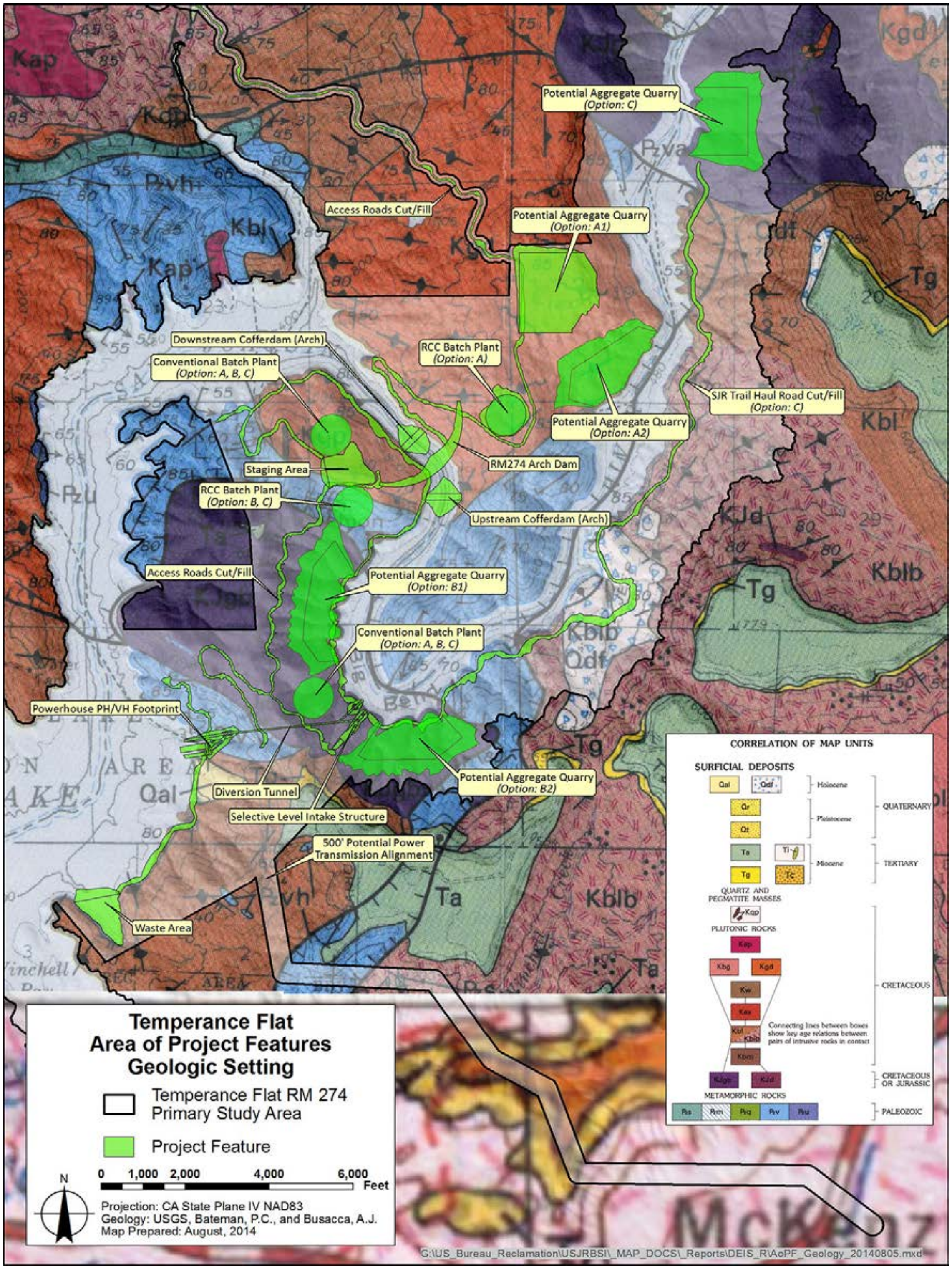
Sources:
[1] *Bateman and Busacca 1982*
[2] *Matthews and Burnett 1966*

Key:
cm = centimeter
mm = millimeter
RM = river mile



Note: Resolution varies across the area shown due to differences in resolution of source maps.

Figure 11-1. Surficial Geology of the Primary Study Area



Note: Resolution varies across the area shown due to differences in resolution of source maps.

Figure 11-2. Geology in the Vicinity of Project Features

The location of the proposed dam and appurtenant facilities rises uniformly from elevation 385 in the original San Joaquin River channel near RM 274. The left abutment location (facing downstream) rises to elevation 1,582 at Pincushion Mountain and the right abutment location (facing downstream) rises to elevation 1,473 at an unnamed mountain. The proposed dam site, both abutment locations, and appurtenant site are mostly granite and granodiorite, with alluvium in the channel section. The granite is typically hard to very hard where exposed in the bottom of drainages and along the reservoir shoreline. The upper 1 to 10 feet of the granite are intensely weathered to decomposed, and soft to very soft. This decomposed granite represents a weathered in-place, soil-like profile at the ground surface.

Hard, erosion-resistant granite outcrops are scattered on the proposed abutment locations. Some outcrops are detached blocks of rock up to 25 feet in maximum dimension. A zone of hard, slightly fractured meta-granite or granite gneiss is present near the dam centerline on the left abutment, and appears to outcrop in a shallow drainage located upstream from the proposed dam centerline on the right abutment.

Alluvium of unknown thickness occurs below the reservoir water surface in the San Joaquin River channel. The alluvium likely ranges from fine to coarse-grained, with rock blocks up to 25 feet in maximum dimension that detached from the slopes near the proposed abutments. No unstable wedges, toppling, or slides were observed at the site (Reclamation 2002a).

Extended Study Area

The various geologic processes active in California over millions of years have created many geologically different areas, called provinces. The upper San Joaquin River lies in the Sierra Nevada Province, and lower San Joaquin River in the Central Valley Province.

The upper San Joaquin River is located in the central portion of the Sierra Nevada Province at its boundary with the eastern edge of the Central Valley Province. The Sierra Nevada Province encompasses the Sierra Nevada, and comprises primarily intrusive rocks, including granite and granodiorite, with some metamorphosed granite and granite gneiss. The province is a tilted fault block nearly 400 miles long, with a high, steep multiple-scarp eastern face and a gently sloping western face that dips beneath the Central Valley Province (CGS 2002a). The central Sierra Nevada has a complex history of uplift and erosion. The greatest uplift tilted the entire Sierra Nevada block to the west. The high elevation of the Sierra Nevada leads to the accumulation of snow, including the Pleistocene glaciation responsible for shaping much of the range. Snowmelt in the Sierra Nevada feeds the San Joaquin River and its major tributaries, including those upstream from Friant Dam, as well as the Merced, Tuolumne, Stanislaus, and Mokelumne rivers and other tributaries downstream from the Merced River confluence. These large rivers and their smaller tributaries cut through the granitic rocks present in the upper San Joaquin River Basin, and through intrusive formations and sedimentary and metamorphosed rocks. The metamorphic bedrock in these watersheds contains gold-bearing veins in the northwest-trending Mother Lode that are not present in the more southerly portion of the upper San Joaquin River Basin. To the south, the Kings River originates in the Sierra Nevada Province and cuts through bedrock similar to the bedrock in the headwaters of the San Joaquin River (CGS 2002b).

At the western border, alluvium and sedimentary rocks overtop the Sierra Nevada Province. Occasional remnants of lava flows and layered tuff are present in the area at the highest elevations. Metamorphic rocks in the Friant Dam area dip steeply downstream to the west, and strike northwesterly. The contact of these metamorphic rocks with the Sierra Nevada batholith lies just east of Friant Dam under Millerton Lake. Friant Dam is founded on metamorphic rocks consisting of quartz biotite schist intruded by aplite and pegmatite dikes, and by inclusions of dioritic rocks. Erosion has resulted in thin colluvial cover (Reclamation 2002a). Intrusive Sierra Nevada batholith rocks underlie most of Millerton Lake and areas immediately upstream from Friant Dam. Surface weathering has produced some decomposed granite and soils.

The Central Valley Province encompasses the Central Valley, an alluvial plain about 50 miles wide and 400 miles long in the central part of California, stretching from just south of Bakersfield to Redding. The San Joaquin Valley makes up approximately half of the Central Valley Province and is drained by the San Joaquin River. The San Joaquin River and its tributaries flow out of the Sierra Nevada Province into the Central Valley, depositing sediments on the alluvial fans, riverbeds, floodplains, and historical wetlands of the Central Valley Province. The Central Valley Province is characterized by alluvial deposits and continental and marine sediments deposited almost continually since the Jurassic Period (CGS 2002b).

The more recent Quaternary Period was characterized by continental sedimentary deposition. Tertiary and Quaternary continental rocks and deposits in the San Joaquin Valley contain lenses of clay and silt comprising lacustrine, marsh, and floodplain deposits. These deposits are of varying thickness, in some instances, thousands of feet thick (Page 1986). These continental deposits, including the Mehrten, Kern River, Laguna, San Joaquin, Tulare, Tehama, Turlock, Riverbank, and Modesto formations, make up the major aquifer system of the San Joaquin Valley (Ferriz 2001, Page 1986). This aquifer system is further discussed in Chapter 13, "Hydrology – Groundwater." The San Joaquin Valley is a structural trough into which sediments have been deposited as much as 6 miles deep. Some of the recent surficial alluvial deposits are mined for aggregate, as discussed below (CGS 2002a). Tectonic activity during the Tertiary Period strongly influenced the evolution of the Central Valley, alternately trapping water in the San Joaquin Valley or entire Central Valley to form inland seas that deposited marine sediments, and opening to allow drainage to the ocean, as under current conditions.

Geologic Hazards

No major faults or shear zones have been identified in the primary study area, and historic seismicity rates are low in the vicinity of the proposed Temperance Flat RM 274 Reservoir (Reclamation 2002b). Reclamation conducted a feasibility design risk analysis in 2009, and concluded that potential wedge formation and sliding due to seismic loading as a significant potential failure mode at the site did not warrant consideration (Reclamation 2009). Therefore, further description of the primary study area is not provided.

The following section provides a regional description of the geologic hazards in the extended study area. Both the Sierra Nevada and Central Valley provinces continue to be subject to minor tectonic activity. Current activity is defined as occurring within the past 1.6 million years, called the Quaternary Period, and continuing through the present day.

Sierra Nevada Microplate Motion

Both the Sierra Nevada and Central Valley provinces are part of the Sierra Nevada microplate, which is one component of a broad tectonically active belt that accommodates motion between the North American Plate to the east and the Pacific Plate to the west. On its eastern side, the Sierra Nevada microplate is bounded by the Sierra Nevada frontal fault system. This system, marked by the steep eastern escarpment of the Sierra Nevada, is characterized by normal and right-lateral strike-slip faults that mark the beginning of the Basin and Range Province. On the west, the microplate is bounded by the fold and thrust belt of the Coast Range Province (Wakabayashi and Sawyer 2001).

Relative to the North American Plate to the east, the right-lateral movement of the Sierra Nevada microplate is 10 to 14 mm/year (0.4 to 0.6 inch per year [in/year]). Its relative right-lateral motion compared to the Pacific Plate to the west is much higher, at 38 to 40 mm/year (1.5 to 1.6 in/year). Internal deformation of the Sierra Nevada microplate is minimal compared to the deformation occurring along its boundaries. However, vertical deformation along the frontal fault system has caused westward or southwestward tilting of the Sierra Nevada block (Bartow 1991; Wakabayashi and Sawyer 2001). Westward tilting has been concurrent with 5,610 to 6,330 feet of uplift by the Sierra Nevada crest over the past 5 million years, equivalent to uplift of 0.34 to 0.39 mm/year (0.013 to 0.015 in/year) (Wakabayashi and Sawyer 2001). This uplift triggered rapid stream incision and deep canyon erosion by the rivers draining the range, including the San Joaquin River and its glacial-meltwater-fed tributaries (Wakabayashi and Sawyer 2001).

Locally, normal faults are found in the Sierra Nevada foothills, probably because the west, or valley, side of the Sierra block is subsiding faster than uplift of the east side (Bartow 1991). One such tensional feature, and west-northwest-trending fault, is thought to be present in the Merced-Chowchilla area based on an offset of a post-Eocene unconformity. This fault may be related to a superficial feature called the Kings Canyon lineament, which crosses the valley north of Chowchilla, parallels the south fork of the Kings River, and continues nearly to Death Valley in the southeast (Bartow 1991). It is unclear whether this fault has been active recently (mapping did not characterize the age of the fault).

San Joaquin Valley Deformation and Subsidence

Regional deposition and deformation patterns of sediments in the San Joaquin Valley have been strongly controlled by recent (Quaternary) tectonic activity (Bartow 1991). Quaternary deposits in the San Joaquin Valley are deformed into a broad, asymmetrical trough with its axis 12 to 19 miles west of the current course of the San Joaquin River (Lettis and Unruh 1991). Valley subsidence is continuing at a rate thought to be a minimum of 0.2 to 0.4 mm/year (0.008 to 0.016 in/year) (Lettis and Unruh 1991). Subsidence is probably due in part to the uplift and tilting of the Sierran block to the west and the Coast Ranges to the east, although the rate of valley subsidence is higher than that of Sierran uplift. It is hypothesized that valley subsidence may also be due to sediment loading and compressional downwarping or thrust loading from the Coast Ranges (Lettis and Unruh 1991). Regional subsidence in the valley is also known to be occurring because of (1) aquifer compaction caused by pumping-related reduction of groundwater levels, as discussed in Chapter 13, “Hydrology – Groundwater,” and (2) compaction and disappearance of soils with high organic content due to development (Reclamation 1997), as discussed in the soils section below.

Active and inactive faults are recognized on both the northern and southern sides of the San Joaquin Valley. On the north, the basin is bounded by the Stockton fault. This fault forms the northern boundary of the Stockton arch, and is a south-dipping reverse fault that runs roughly west-northwest across the valley (Bartow 1991). Faulting at the southern boundary of the San Joaquin Valley is concentrated around the Bakersfield arch, a broad southwest plunging subsurface ridge (Bartow 1991). Few faults fall north of the Bakersfield arch, which offset Quaternary sediments, suggesting a lack of recent (Quaternary) tectonic activity (Bartow 1991). The Pond and Greeley fault systems are two major buried structures recognized to have normal offsets of as much as 1,640 to 2,020 feet, but offsets decrease upward so that no deposits younger than late Miocene have shifted. Similarly, neither the Clovis fault, about 5 miles from the City of Clovis, nor the Foothills fault system, comprising the Bear Mountain and Melones fault zones about 70 to 80 miles north of Fresno, are considered to have been active in the Quaternary period. Additionally, a series of northwest-trending lineaments is exposed at the surface around the Kern River, but they have not been shown to be connected with subsurface faults (Bartow 1991). However, the Nunez reverse fault, located 7 miles northwest of Coalinga, was first mapped after it ruptured during the 1983 Coalinga earthquake and its aftershocks (Lin and Stein 2006). Details of the timing and total offset along the fault remain unknown.

The easternmost fault subsystem separating the Central Valley from the Coast Ranges is the Great Valley blind thrust, part of the San Andreas Fault system. This reverse fault separates Great Valley sequence deposits on the east from Franciscan rocks on the west. The fault subsystem comprises at least 14 segments along an extent of over 300 miles, although precise locations of its surface traces are not well documented (USGS 1996). The Great Valley thrust system is thought to accommodate a nominal 0.5 to 1.5 mm/year (0.02 to 0.06 in/year) of motion (CGS 2002c, USGS 1996).

Ground Shaking and Liquefaction Hazards

Although a fault rupture can cause significant damage along its narrow surface trace, earthquake damage is mainly caused by strong, sustained ground shaking (WG02 2003). Seismic ground shaking can also cause soils and unconsolidated sediments to compact and settle. If compacted soils or sediments are saturated, pore water is forced upward to the ground surface, forming sand boils or mud spouts. This soil deformation, called liquefaction, may cause minor to major damage to infrastructure. Earthquake ground shaking hazard potential is low in most of the San Joaquin Valley and Sierra Nevada foothills (CSSC 2003). Although the San Joaquin Valley is not considered to be a high-risk liquefaction area because of its generally low earthquake and ground shaking hazard risk, it can be assumed that some liquefaction risk exists throughout the valley in areas where unconsolidated sediments and a high water table coincide, such as near rivers and in wetland areas (Merced County 2007).

Erosion and Sedimentation

The sediment load of the San Joaquin River and its tributaries originates from the erosion of soil and rock units of the Sierra Nevada Province, as discussed above. In upstream reaches of the San Joaquin River, the sediment load generally comprises large boulders, cobbles of diameters greater than or equal to 4 inches, fine sand, and less commonly, intermediate-sized gravels (SCE 2003). Direct erosion and mass wasting (movement of material downslope under the influence of gravity) into the watercourses is the primary reason that angular to subangular, medium- to coarse-grained sands and large boulders make up most of the substrate of granitic watersheds, like that of the San Joaquin River above Millerton Lake (SCE 2003).

Soil erosion and sediment transport in the Study Area are described below.

Soil Erosion Potential

Natural physical and chemical forces constantly work to break down soils. This process, called erosion, has two effects. First, erosion removes soils, undermining structures like bridges and forming unstable slopes. Second, erosion deposits these soils in low-lying areas, causing sedimentation of streams and reservoirs. Erosion also results in landslides that may damage roads, buildings, and other infrastructure. Soil characteristics that affect the erosion rate are soil surface texture and structure, particle size, permeability, infiltration rate, and the presence of organic or other cementing materials. Other key factors determining erosion potential are the extent of vegetation, type of vegetative cover, human or other disturbance, topography, and rainfall.

Along the San Joaquin River above Friant Dam, soils on steep, un-vegetated slopes are particularly vulnerable to erosion, especially on slopes greater than 30 percent (Fresno County 2000). Approximately 6,000 acres of soils in the primary study area have slopes equal to or exceeding 30 percent (Soil Survey Staff 2013). Since natural and cut slopes in decomposed granite soils erode readily, soils are particularly vulnerable to erosion in the Sierra Nevada and foothills (FERC 2002). In the San Joaquin Valley, the bluffs of the San Joaquin River below Friant Dam are steep and exhibit severe erosion potential (Fresno County 2000).

Human activities can also accelerate natural erosion processes. The greatest cause of localized sedimentation problems is construction and development, which usually involves vegetation removal, compaction of porous soils, and drainage of large areas. In particular, road building and timber harvesting have the greatest potential to increase erosion that results in watercourse sedimentation (SCE 2003). Improper agricultural management practices can also accelerate erosion. Overgrazing and land clearing, particularly on steep slopes, but also on flat areas, make surfaces vulnerable to topsoil loss (Rojstaczer et al. 1991).

Infrastructure Effects on Sediment Transport

The most significant effect of dams and storage reservoirs on a watershed is on sediment supply because they serve as impediments to sediment transport downstream. Because of the slowing of river velocity in the reservoir that forms behind a dam, river carrying capacity decreases and the sediment load drops out of the water column and onto the channel bottom. Although the water and some of its fine sediment may be released on the downstream side of the dam, the majority of the sediment load, particularly the coarse materials, remains on the upstream side. This sediment accumulation may be so marked that over time it can significantly decrease the storage volume of the reservoir itself.

Removal of accumulated sediments can also be problematic. In the past, sluicing to remove sediments from the relatively small Kerckhoff Reservoir (storage volume of 4,000 acre-feet) on the San Joaquin River immediately upstream from Friant Dam resulted in extremely high levels of sediment downstream, although flood flows in intervening years may have flushed these sediments from the river into Millerton Lake (SCE 2003). Dam operations also limit the release of flows to downstream reaches, reducing the frequency of sediment-transporting flows in most years (SCE 2007). Major dams with potential to limit sediment supply to the main stem San Joaquin River and its major tributaries, along with their corresponding reservoirs and volumes, are listed in Table 11-2. As shown in Table 11-3, the San Joaquin River Basin upstream from RM 274 is highly modified; the dams in this watershed have modified not only the hydrology but also the sediment regime of the watershed.

Table 11-2. Major Dams and Reservoirs with Storage Capacity Greater than 50,000 Acre-Feet in the San Joaquin River Basin

River	Reservoir/Dam[1]	Volume (TAF)	Year Completed	Operating Agency[2]
Calaveras	New Hogan	317	1965	USACE
Chowchilla	Eastman/Buchanan	150	1975	USACE
Fresno	Hensley/Hidden	90	1974	USACE
Kaweah	Kaweah/Terminus	183	1962	USACE
Kern	Isabella	570	1953	USACE
Kings	Pine Flat	1,000	1954	USACE
Merced	McClure/New Exchequer	1,032	1967	Merced ID
Mokelumne	Camanche	341	1964	EBMUD
San Joaquin	Millerton/Friant	520	1942	Reclamation
Stanislaus	New Melones	2,400	1979	Reclamation
Tule	Success	82	1961	USACE
Tuolumne	New Don Pedro	2,031	1971	Turlock and Modesto IDs

Notes:

[1] The dam name is only listed when it differs from the reservoir name.

[2] For reservoirs with a Federal flood control purpose, USACE is the operating agency during the flood control season. Refer to Chapter 12, “Hydrology – Flood Management,” for more information.

Key:

EBMUD = East Bay Municipal Utility District
ID = Irrigation District
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
TAF = thousand acre-feet
USACE = U.S. Army Corps of Engineers

Table 11-3. Dams in the San Joaquin River Basin Upstream from River Mile 274[1]

Name of Dam	Name of Lake	Distance from RM 274 (RM)	Name of River/Creek	Normal Storage Capacity (TAF)
Kerckhoff Dam	Kerckhoff Reservoir	18.53	San Joaquin River	4.3
Redinger Dam (Big Creek Dam No. 7)	Redinger Lake	27.4	San Joaquin River	26.1
Big Creek Dam No. 6	NA	38.4	San Joaquin River	1
Mammoth Pool Dam	Mammoth Pool	47.9	San Joaquin River	120
Manzanita Diversion Dam	Manzanita Lake	43.66	North Fork Willow Creek	0.164
Crane Valley Dam	Bass Lake	41.6	North Fork Willow Creek	45.4
Chilkoot Dam	Chilkoot Lake	61.63	Chilkoot Creek	0.31
Shaver Lake Dam	Shaver Lake	39.5	Stevenson Creek	135
Big Creek Dam No. 5	NA	40.2	Big Creek	0.05
Balsam Meadow Forebay Main Dam	Balsom Meadow Forebay	52.99	Tributary of Balsam Creek	1.55
Big Creek Dam No. 4	NA	43.4	Big Creek	0.06
Big Creek Dam No. 1, 2, 3, and 3a	Huntington Lake	46.1[2]	Sheep Thief Creek	89.8
Rutherford Dam	Rutherford Lake	86.27	Tributary of West Fork Granite Creek	0.2
McClure Dam	McClure Lake	87.36	Tributary of East Fork Granite Creek	0.21
Vermillion Valley Dam	Thomas A. Edison Lake	90.3	Mono Creek	125
Portal Forebay Main Dam	Portal Forebay	86.15	Camp Sixty One Creek	0.33
Bear Creek Diversion Dam	NA	90.53	Bear Creek	0.1
Florence Lake Dam	Florence Lake	87.6	South Fork San Joaquin River	64.4

Source: Stanford University, 2014.

Note:

[1] Excludes dams impounding less than 100,000 acre-feet.

[2] Big Creek Dam No. 3 used for river mile measurement

Key:
No. = Number
PG&E = Pacific Gas and Electric
RM = river mile
SCE = Southern California Edison
TAF = thousand acre-feet

Under unaltered conditions, geomorphic fluvial processes, including sediment transport, occur on a relatively consistent basis along the length of a river, and flow energy in the river channel is dissipated gradually. Bridges and culverts constrict the natural channel and disrupt these processes, which also alter channel form. This may occur at either high or low flows, depending on the size of the structure.

In the extended study area, the effects of channel constrictions caused by bridge and culvert crossings include the following:

- Sediment deposition upstream from the constriction (backwater effects)
- Scour at the constriction due to an elevated water surface and increased water velocity
- Sediment deposition downstream from the constriction due to flow expansion and velocity reduction, leading to the formation of splay bars
- Reduced flood conveyance capacity due to filling in of floodplain space when building bridge and culvert abutments

The function and operation of the water supply and flood management infrastructure present in the Study Area also affect fluvial processes of the San Joaquin River. Such infrastructure includes diversion structures, bypasses and bypass diversions, other hydraulic control structures, offstream flood control dams, levees, and canals. These structures divert base flows and/or flood flows and thereby significantly alter fluvial processes. The processes most affected are sediment transport, local incision and deposition, and channel migration (Table 11-4).

Table 11-4. Generalized Effects on Geomorphic Processes of Major Flood Management and Water Supply Infrastructure

Infrastructure	Effects
Diversion structures	Backwater effects cause disruption of local incision and deposition patterns; riprap protection prevents channel migration and avulsion; reroute sediment load.
Bypasses	Reroute sediment load within the extended study area.
Bypass diversion structures	Backwater effects cause disruption of local incision and deposition patterns; reroute sediment load within the extended study area.
Other hydraulic control structures	Backwater effects cause disruption of local incision and deposition patterns; reroute sediment load within the primary and extended study areas.

Table 11-4. Generalized Effects on Geomorphic Processes of Major Flood Management and Water Supply Infrastructure (contd.)

Infrastructure	Effects
Offstream flood control dams	Reroute sediment load within the Study Area.
Levees	Dissect the historic floodplain; stop channel migration and avulsion; and increase river velocity and, thus, also increase incision, bed armoring, and channel simplification.
Canals	Embankments dissect the historic floodplain; stop channel migration and avulsion; reroute sediment load; and increase river velocity and, thus, also increase incision, bed armoring, and channel simplification.

Sediment load is carried by flows, and all infrastructure that reroutes flows alters sediment transport within the watershed. Flood control bypasses, in particular, divert most of the sediment load of the San Joaquin River directly to the bypass system. This results in a long-term effect on river sedimentation patterns. Small diversion structures, including the Chowchilla Bypass Bifurcation Structure, Mendota Dam, Sack Dam, Sand Slough Control Structure, and the Eastside Bypass Bifurcation Structure, also affect sediment transport by modifying the delivery of sediment downstream. Diversion and other hydraulic control structures may constrict the river channel, which alters local incision and deposition patterns, as described above. Levees and canal embankments dissect the historic floodplain, which prevents channel migration and avulsion. This prevents oxbow formation and also increases river velocity, which encourages channel incision, bed armoring, and channel simplification.

Geomorphology

Geomorphologic characteristics of the primary and extended study areas are described in the following sections.

Primary Study Area

Millerton Lake is set in the lower foothills of the Sierra Nevada, is fairly open, and is mostly surrounded by low hills. Tributaries to Millerton Lake include Winchell and Fine Gold creeks in the downstream portion, and Big Sandy Creek in the upstream or Temperance Flat area.

The San Joaquin River upstream from Temperance Flat lies in a steep and narrow canyon with a bedrock channel that has an overall average gradient of about 1 percent, many long narrow pools, and an occasional steep cascade. One unnamed perennial drainage and 78 intermittent drainages enter the San Joaquin River in this reach. There are 183 ephemeral drainages in the primary study area (Reclamation 2008 and 2010). Most of the river margins are steep and rocky and flood flows frequently scour the channel.

Extended Study Area

Major tributaries to the San Joaquin River downstream from Friant Dam, including the Merced, Tuolumne, Stanislaus, and Mokelumne rivers, flow west out of the Sierra Nevada to join the San Joaquin River. South of the San Joaquin River, the Kings River flows west out of the Sierra Nevada. Similar to the San Joaquin River, these tributary rivers lie in steep, narrow canyons in the Sierra Nevada and foothills, then flow west into the Central Valley over broad, open alluvial fans and floodplains.

The San Joaquin Valley floor is divided into several geomorphic land types, including dissected uplands, low alluvial fans and plains, river floodplains and channels, and overflow lands and lake bottoms. The dissected uplands consist of consolidated and unconsolidated continental deposits of Tertiary and Quaternary age that have been slightly folded and faulted.

The alluvial fans and plains consist of unconsolidated continental deposits that extend from the edges of the valleys toward the valley floor. The alluvial plains cover most of the valley floor and make up some of the intensely developed agricultural lands in the Central Valley. Alluvial fans along the Sierra Nevada consist of high percentages of clean, well-sorted gravel and sand. Fans from Coast Range streams are less extensive. West-side fans tend to be poorly sorted and contain high percentages of fine sand, silt, and clay. Interfan areas between major alluvial fans of the east side are drained by smaller intermittent streams similar to those on the west side. Thus, these interfan areas tend to be poorly sorted and have lower permeabilities than main fan areas. In general, alluvial sediments of the western and southern parts of the Central Valley tend to have lower permeability than east-side deposits.

River floodplains and channels lay along the major rivers and to a lesser extent the smaller streams that drain into the valley from the Sierra Nevada. Some floodplains are well defined where rivers incise their alluvial fans. These deposits tend to be coarse and sandy in the channels and finer and silty in the floodplains. Lake bottoms of overflow lands include historical beds of Tulare Lake, Buena Vista Lake, and Kern Lake, as well as other less defined areas in the valley trough.

Mineral Resources

In 2011, California ranked seventh in the nation in nonfuel mineral production. In that year, California yielded $2.9 billion in nonfuel minerals, totaling 4 percent of the nation's entire production (Clinkenbeard and Smith 2011). The value and quantity produced of the most economically important products in the State are summarized in Table 11-5. Of these products, construction sand and gravel are the most widely mined resources in the vicinity of the San Joaquin River. Historically, gold was also extracted from the riverbed of the San Joaquin River and its tributaries. Information in this section is presented at the available regional resolution.

Sand, Gravel, and Other Rock Products

In 2011, California produced 120.5 million tons of aggregate, including sand, gravel, and crushed stone, an increase over production in 2010. Portland cement production also increased over 2010, to 8.3 million tons (Table 11-5). Together, the market value of these products totaled $1.5 billion, just over 50 percent of the total value of State nonfuel mineral production (Clinkenbeard and Smith 2011).

Table 11-5. California Nonfuel Mineral Production in 2011

Product	Quantity (short tons)	Value ($ millions)
Construction sand and gravel	87,277,000	590.5
Industrial sand and gravel	1,500,000	39.4
Portland cement	8,279,000	587.4
Masonry cement	172,000	16.6
Dimension stone	31,800	6.7
Crushed stone	33,700,000	295.4
Common Clays	393,000	5.4
Gold	6.8	323.7
Gemstones	NA	0.7
Total[1]	NA	2,897.0

Source: Clinkenbeard and Smith 2011

Note:

[1] Total includes values not listed to avoid disclosing company proprietary data, including boron minerals, other clays (bentonite, fire, and kaolin), diatomite, feldspar, gypsum, iron ore, lime, magnesium compounds, perlite, pumice and pumicite, rare earths, salt, soda ash, silver, sodium sulfate, talc, and zeolites.

Key:
NA = Not available

The California Department of Conservation, Division of Mines and Geology, maps mineral resource zones in California, based on the mineral resource potential of that land. According to the mapping completed in the Fresno area, the San Joaquin River below Friant Dam is a significant source of sand and gravel in the State, and mining occurs at multiple locations on the floodplain and river terraces. The California Department of Conservation, Division of Mines and Geology, reported the total quantity of aggregate available in the Fresno area (including the San Joaquin and Kings river areas in Fresno, Madera, and Kings counties) as approximately 2.2 billion tons (including permitted and non-permitted sources) (Youngs and Miller 1999). The San Joaquin River area upstream from Friant Dam has not been mapped as part of a mineral resource zone.

Gold

Historically, gold was mined from quartz veins in the Mother Lode of the northern Sierra Nevada as well as from placer deposits in loosely consolidated alluvial sediments throughout the Sierra Nevada foothills. These activities significantly reworked the riverine environments, redistributing sediments and altering channel forms. However, the San Joaquin River was less affected by dredge mining than the more northerly Sierra Nevada drainages, where gold was more plentiful (McBain & Trush 2002).

A survey conducted in 2003 by BLM in support of the Investigation identified three abandoned mine sites within the Temperance Flat Reservoir Area, including the Patterson Mine (formerly known as the Diana Mine), San Joaquin Mine, and the Sullivan Mine Group. These mines include multiple audits and millsites (Springer 2005).

Soils

The following section describes soils in the primary and extended study areas. Because of the nature of the resource, the extended study area is described from a regional perspective.

Primary Study Area

The primary study area, including the Millerton Lake watershed area, includes eight soil associations. These soils have been described to vary between a few inches up to 6 feet in depth. A generalized description of each of the soils in the primary study area is provided in Table 11-6.

Table 11-6. Generalized Soils in the Vicinity of the Primary Study Area

General Soil Map, Eastern Fresno Area, California	
Soil Association	**General Features**
Auberry-Ahwahnee Association	Auberry-Ahwahnee association soils are described as well drained and somewhat excessively drained sandy loams. These sandy loams are moderately deep and deep over granitic rocks.
Coarsegold Association	Coarsegold association soils are described as somewhat excessively drained fine sandy loams that are deep over metasedimentary rock.
Trimmer-Trabuco Association	Trimmer-Trabuco association soils are described as well drained and somewhat excessively drained sandy loams to loams. These sandy loams are moderately deep and deep over igneous rock.

Table 11-6. Generalized Soils in the Vicinity of the Primary Study Area (contd.)

Soil Survey of the Madera Area, California	
Soil	**General Features**
Madera Sandy Loam	Madera sandy loam extends to a depth of 1 feet to 6 feet and is characterized as light-brown to dark-brown sandy loam.
San Joaquin Sandy Loam	San Joaquin sandy loam extends to a depth of 18 inches to 6 feet and is characterized as reddish-brown to yellowish-brown sandy loam, which is underlain by dense impenetrable red hardpan.
Rough Stony Sand	Rough stony sand exists in hilly areas and elevated plateaus.
Hanford Sandy Loam	Hanford sandy loam extends to a depth of 6 feet or more and is characterized as light-brown, grayish-brown, or buff-colored micaceous sandy loam.
Daulton Sandy Loam	Daulton sandy loam extends to a depth from 6 inches to 4 feet and is characterized as grayish to dark brown.

Source: U.S. Department of Agriculture, Soil Conservation Service 1970; Strathorn et al 1910

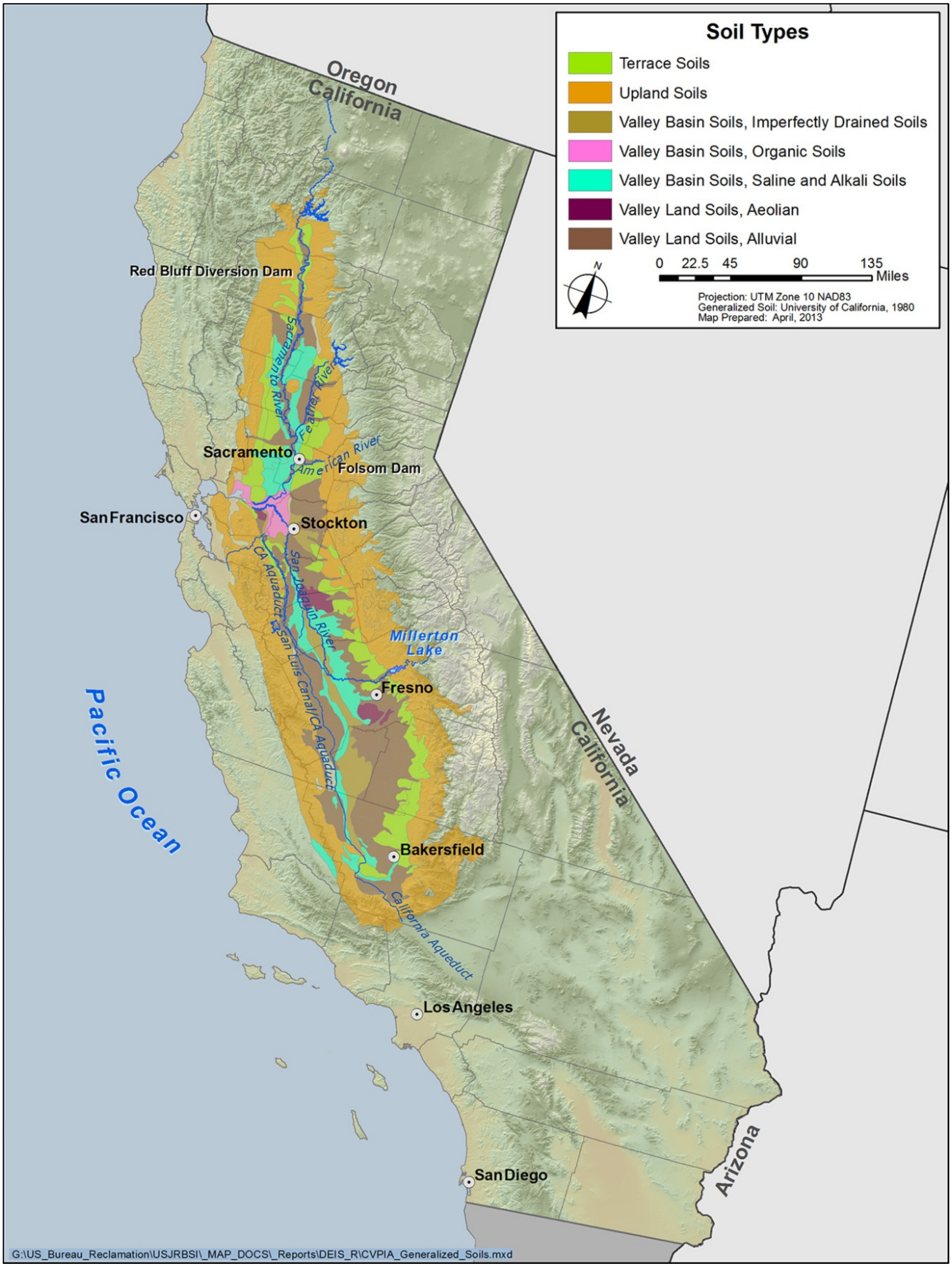
Extended Study Area

The development of individual soils is based largely on parent material, climate, associated biology, topography, and age. These factors combine to create the more than 2,000 unique soils in the State. Because these factors are similar within physiographic regions, soils in the vicinity of the San Joaquin River are described here according to four distinct physiographic regions: valley basin land, valley land, terrace land, and upland, as summarized in Table 11-7. Valley basin land and valley land soils occupy most of the San Joaquin Valley floor, including the Delta, as shown in Figure 11-3. Valley land soils consist of deep alluvial and aeolian soils that make up some of the best agricultural land in the State. Valley basin land soils consist of organic soils, imperfectly drained soils, and saline and alkali soils in the valley trough and on the basin rims. Areas above the San Joaquin Valley floor consist of terrace land and upland soils, on higher elevations and steeper slopes. Overall, these soils are not as productive as the valley land and valley basin land soils. Without irrigation, these soils are primarily used for grazing and timberland; with irrigation, additional crops can be grown. These soil types and their geographic extents are described in detail below, followed by a brief description of soil salts in the San Joaquin Valley, an important feature of some soils.

Table 11-7. Summary of Soils in San Joaquin River Basin

Physiographic Region	Location	Texture
Valley Basin Land		
Organic Soils	Sacramento-San Joaquin Delta	Peat, organic
Imperfectly Drained Soils	Sacramento-San Joaquin Valley trough	Clays
Saline/Alkaline Soils	West side of San Joaquin Valley	Clay loam–clay
Valley Land		
Alluvial Soils	Alluvial fans and low terraces in Sacramento-San Joaquin Valley	Sandy loam–loam
Aeolian Soils	Portions of Stanislaus, Merced, and Fresno counties	Sands–loamy sand
Terrace Land		
Brown, Neutral Soils	West side of Sacramento Valley and southeast San Joaquin Valley	Loam–clay
Red-Iron Hardpan Soils	East side of Sacramento and San Joaquin valleys	Sandy loam–loam hardpan
Upland		
Shallow Depth to Bedrock	Foothills surrounding Central Valley	Loam–clay loams
Moderate Depth to Bedrock	East side of Merced and Stanislaus counties	Sandy loam–clay loam
Deep Depth to bedrock	Higher elevations of Sierra Nevada, Klamath Mountains, and Coast Range	Loam–clay loams

Source: University of California, Division of Agricultural Sciences 1980



Source: University of California 1980

Figure 11-3. Physiographic Region Soil Types in the Central Valley and Delta

Valley Basin Land Valley basin land soils occupy the lowest parts of the San Joaquin Valley and the Delta. These soils fall into three categories: organic soils, imperfectly drained soils, and saline/alkali soils.

- **Organic Soils –** Organic soils are so named because of their high organic matter content, which is 12 percent or more by weight and typically greater than 50 percent in the upper layers. These soils are typically dark and acidic because of their high organic matter content, and are usually referred to as peat. They often form in areas that are frequently saturated with water (poorly drained), and are therefore common in the Delta, at the downstream end of the San Joaquin River.

- **Imperfectly Drained Soils –** This category of soils generally contains dark clays and has a high water table or is subject to overflow. These soils are found in the trough of the San Joaquin Valley, and are present in parts of several thick lake-bed deposits.

- **Saline/Alkali Soils –** These soils are characterized by excess salts (saline), excess sodium (sodic), or both (saline-sodic). In many of the older soil surveys, salinity and sodicity were jointly referred to as alkaline. A distinction was sometimes made because the saline soil many times formed a white crust on the surface and was called “white alkali,” and the soils with excess sodium appeared to be “black,” thus, black alkali. Both are fairly common throughout the San Joaquin Valley. In uncultivated areas, saline soils are used for saltgrass pasture and native range. Some of these soils support seasonal salt marshes. In areas of intermediate to low rainfall, the soils have excess sodium as well as salt. Many of these soils are irrigated with moderately saline Delta surface water, imported via the DMC and California Aqueduct, or with slight to moderately saline groundwater. In addition, salts are added through the application of fertilizers or other additives needed for farming. This saline addition to already saline soils forms a crust on top of the soils, changes the chemical characteristics of the soils in the root zone, and reduces the capability of the soils to transfer applied moisture to the roots. To minimize salinity problems, irrigators apply water to the soil before planting seed or plants to leach salts from the root zone. Leaching is complicated by poor drainage, low permeability, and high sodium content. Leaching increases salinity in the groundwater aquifers, which further exacerbates the salinity problem because the saline groundwater is used for irrigation. Because of the rise in groundwater salinity, the area with soil salinity problems has grown. This most recently occurred during the 1987 to 1994 drought, when surface water availability was limited and groundwater use escalated. Leaching also increases the salinity in flows from subsurface drains, which affects water quality in surface waters that receive return flows, or the quality of water and sediments in evaporation ponds. The increase in groundwater salinity and its effects on the capability of land to be used for irrigated crops are further discussed in Chapter 13, "Hydrology – Groundwater."

Valley Land Valley land soils are generally found on flat to gently sloping surfaces, such as on alluvial fans. These well-drained soils include some of the best all-purpose agricultural soils in the State. Both alluvial- and aeolian-deposited soils are present in the San Joaquin Valley.

- **Alluvial Soils** – Alluvial-deposited valley land soils include calcic brown, noncalcic brown, and gray desert alluvial soils. Figure 11-3 shows the distribution of all San Joaquin Valley alluvial soils. Calcic brown and noncalcic brown alluvial soils are found in the San Joaquin Valley on deep alluvial fans and floodplains occurring in areas of intermediate rainfall (10 to 20 inches annually). These two soils tend to be brown to light brown with a loam texture that forms soft clods. Calcic brown soil is calcareous; noncalcic soil is usually neutral or slightly acid. These soils are highly valued for irrigated crops such as alfalfa, apricots, carrots, corn, lettuce, peaches, potatoes, sugar beets, and walnuts. Where the climate is suitable, avocados, citrus fruits, cotton, and grapes can be grown. These soils are found in the northern and central San Joaquin Valley. Gray desert alluvial soil is found on alluvial fans and floodplains that receive low rainfall (4 to 7 inches annually). This soil appears in the western San Joaquin Valley as light-colored calcareous soil that is low in organic matter. These soils are too dry to produce crops without irrigation. When irrigated, these soils are valued for alfalfa, cotton, and flax.

- **Aeolian Soils** – Aeolian-deposited and wind-modified soils found in the east side of the San Joaquin Valley are noncalcic brown sand soils. These soils are prone to wind erosion, have low water-holding capacity, and are somewhat deficient in plant nutrients.

Terrace Land Terrace land soils are found along the edges of the San Joaquin Valley at elevations of 5 to 100 feet above the valley floor. Several groups of terrace soils surround the floor of the Central Valley. Two of the more widespread groups are discussed in the following paragraphs. Terrace land soils are grouped together and shown in Figure 11-3.

- **Brown Neutral Soils** – The first group consists of moderately dense, brownish soils of neutral reaction. These soils are found in areas receiving 10 to 20 inches of rain per year. In the southeastern San Joaquin Valley, these soils tend to have a clay texture. This soil group is commonly used for irrigated pasture; however, citrus orchards are grown on some of these soils. Following ripping (e.g., deep tilling), these soils are suitable for orchard and vineyard development.

- **Red Iron Pan Soils** – A second type of terrace soil has a red-iron hardpan layer and is found along the east side of the San Joaquin Valley. These soils consist of reddish surface soil with a dense silica-iron cemented hardpan, which is generally 1 foot thick. Some of these hardpan soils have considerable amounts of lime. These soils occur in areas receiving 7 to 25 inches of rain per year. Dry farming practices have fair results with hay, grains, and pastures. Following ripping, these soils are well suited for orchards and vineyards.

Upland Soils Upland soils are found on hilly to mountainous topography and are formed in place through decomposition and disintegration of the underlying parent material. The more widespread upland soil groups include shallow depth, moderate depth, and deep depth to bedrock. Two upland soil groups, shallow depth and moderate depth, are more common because of their geographic location and elevation. Upland soils are found around the perimeter of the San Joaquin Valley, as shown in Figure 11-3. Soils on the west side have mostly developed on sedimentary rocks while those on the east side typically developed on igneous rocks.

- **Shallow Depth to Bedrock –** This group of upland soils is found in the Sierra Nevada and Coast Range foothills that surround the San Joaquin Valley. The soils have a loam-to-clay-loam texture with low organic matter, and some areas have calcareous subsoils. These soils usually have a shallow depth to weathered bedrock (less than 2 feet). These soils are found in areas of low to moderate rainfall that support grasslands used primarily for grazing. Tilled areas are subject to considerable erosion.

- **Moderate Depth to Bedrock –** This group of upland soils is found on hilly to steep upland areas having medium rainfall and that can support grasslands. These soils have a sandy-loam-to-clay-loam texture and moderate depth to weathered bedrock, about 2 feet. This slightly acidic soil group is dark and is found in the Stanislaus County and Merced County foothills east of the valley floor.

- **Deep Depth to Bedrock –** This group of upland soils is found at the higher elevations in the Sierra Nevada and Coast Range on hilly to steep topography. These soils are characterized by a moderate to strongly acidic reaction, especially in the subsoils, which can extend 3 to 6 feet before reaching bedrock. Bedrock consists of meta-sedimentary and granitic rocks. Soils forming on granitic rocks consist of decomposed granitic sands. These soils receive 35 to 80 inches of precipitation per year and support extensive forests.

Salts

The accumulation of salts in the soils of the San Joaquin Valley is due to a combination of the regional geology, high water table, intensive irrigation practices, and the application of imported high-salinity water from the Delta. The Corcoran Clay and other clay layers contribute to a naturally high water table in the valley, concentrating salts in the root zone by evaporation through the soil. Landowners actively leach these salts from the soil into drainage water with irrigation and subsurface drainage practices. Drainage water with high concentrations of salts may be reused for irrigation (with or without treatment), accumulate in groundwater, or be discharged to evaporation ponds or tributaries to the San Joaquin River. Salinization caused by concentrations of naturally occurring soil salts is exacerbated by the use of more saline Delta water, imported via the DMC and California Aqueduct, as a major source of irrigation water.

Additionally, naturally occurring trace elements in soils may be mobilized and concentrated along with salts. Soils throughout the San Joaquin Valley typically contain some selenium, and soils on the west side of the valley are particularly selenium rich. These soils have developed on alluvial deposits comprising eroded material from the Coast Range, where selenium is found in marine deposits. Selenium can pose a hazard to fish and wildlife when it becomes highly concentrated in surface waters.

The salinization of soils and water in the San Joaquin Valley is causing loss of agricultural production and damage to local water infrastructure, including pipes, pumps, and water heaters. To address this ongoing problem, the State Water Board, the Central Valley Water Board, and a multifaceted stakeholder group named the Central Valley Salinity Coalition have teamed to lead efforts to identify and manage salt sources and processes causing salt loading in the San Joaquin Valley. Through the program CV-SALTS, this diverse group is devising a collaborative basin planning effort aimed at developing and implementing a comprehensive salinity and nitrate management strategy. Reclamation has also agreed to participate in salinity control efforts in the lower San Joaquin River Basin, as described in its Management Agency Agreement with the Central Valley Water Board.

Total Maximum Daily Loads (TMDL), which define a maximum acceptable level of loading of a particular constituent in surface water, exist, or are currently being developed, for salts in the San Joaquin River and several tributaries. More information on salt-related TMDLs, as well as a more detailed description of water quality conditions in the Study Area, is presented in Chapter 15, “Hydrology – Surface Water Quality.”

Environmental Consequences and Mitigation Measures

This section describes potential environmental consequences on geology and soils that could result from implementing any of the alternatives. It also describes the methods of environmental evaluation, assumptions, and specific criteria that were used to determine the significance of impacts on geology and soils. It then discusses the potential impacts and proposes mitigation where appropriate. The potential impacts on geology and soils and associated mitigation measures are summarized in Table 11-8.

Table 11-8. Summary of Impacts and Mitigation Measures for Geology and Soils

Impact	Study Area	Alternative	Level of Significance Before Mitigation	Mitigation Measure	Level of Significance After Mitigation
GEO-1: Exposure of Structures and People to Geologic Hazards Resulting from Seismic Conditions and Slope Instability	Primary Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	PS	GEO-1: Develop and Implement a Seismic Action Plan	LTS
		Alternative Plan 2	PS		LTS
		Alternative Plan 3	PS		LTS
		Alternative Plan 4	PS		LTS
		Alternative Plan 5	PS		LTS
	Extended Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	NI		NI
		Alternative Plan 2	NI		NI
		Alternative Plan 3	NI		NI
		Alternative Plan 4	NI		NI
		Alternative Plan 5	NI		NI
GEO-2: Alteration of Fluvial Geomorphology that would Adversely Affect Aquatic Habitat	Primary Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	PS	None Available	PSU
		Alternative Plan 2	PS		PSU
		Alternative Plan 3	PS		PSU
		Alternative Plan 4	PS		PSU
		Alternative Plan 5	PS		PSU
	Extended Study Area	No Action Alternative	LTS	None Required	LTS
		Alternative Plan 1	LTS		LTS
		Alternative Plan 2	LTS		LTS
		Alternative Plan 3	LTS		LTS
		Alternative Plan 4	LTS		LTS
		Alternative Plan 5	LTS		LTS

Table 11-8. Summary of Impacts and Mitigation Measures for Geology and Soils (contd.)

Impact	Study Area	Alternative	Level of Significance Before Mitigation	Mitigation Measure	Level of Significance After Mitigation
GEO-3: Loss or Diminished Availability of Known Mineral Resources that Would Be of Future Value to the Region or the State	Primary Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	LTS		LTS
		Alternative Plan 2	LTS		LTS
		Alternative Plan 3	LTS		LTS
		Alternative Plan 4	LTS		LTS
		Alternative Plan 5	LTS		LTS
	Extended Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	LTS		LTS
		Alternative Plan 2	LTS		LTS
		Alternative Plan 3	LTS		LTS
		Alternative Plan 4	LTS		LTS
		Alternative Plan 5	LTS		LTS
GEO-4: Substantial Soil Erosion or Loss of Topsoil Due to Construction and Operations	Primary Study Area	No Action Alternative	NI	None Available	NI
		Alternative Plan 1	PS		PSU
		Alternative Plan 2	PS		PSU
		Alternative Plan 3	PS		PSU
		Alternative Plan 4	PS		PSU
		Alternative Plan 5	PS		PSU
	Extended Study Area	No Action Alternative	LTS	None Required	LTS
		Alternative Plan 1	LTS		LTS
		Alternative Plan 2	LTS		LTS
		Alternative Plan 3	LTS		LTS
		Alternative Plan 4	LTS		LTS
		Alternative Plan 5	LTS		LTS

Table 11-8. Summary of Impacts and Mitigation Measures for Geology and Soils (contd.)

Impact	Study Area	Alternative	Level of Significance Before Mitigation	Mitigation Measure	Level of Significance After Mitigation
GEO-5: Failure of Septic Tanks or Alternative Wastewater Disposal Systems Due to Soils that Are Unsuited to Land Application of Waste	Primary Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	LTS		LTS
		Alternative Plan 2	LTS		LTS
		Alternative Plan 3	LTS		LTS
		Alternative Plan 4	LTS		LTS
		Alternative Plan 5	LTS		LTS
	Extended Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	NI		NI
		Alternative Plan 2	NI		NI
		Alternative Plan 3	NI		NI
		Alternative Plan 4	NI		NI
		Alternative Plan 5	NI		NI

Key:
LTS = less than significant
NI = no impact
PS = potentially significant
PSU = potentially significant and unavoidable

Methods and Assumptions

The analysis presented in this chapter is qualitative and based on the general information on geology, soils, mineral resources, seismicity and neotectonics, and geomorphology documented for the region, as previously described. Impacts associated with geology and soils that could result from project construction and operational activities were evaluated qualitatively, based on expected construction practices, materials, locations, and duration of project construction and related activities, as well as the impacts of reservoir operations at the proposed Temperance Flat RM 274 Dam and Reservoir and Millerton Lake.

Criteria for Determining Significance of Impacts

An environmental document prepared to comply with NEPA must consider the context and intensity of the environmental impacts that would be caused by, or result from, implementing the No Action Alternative and the range of action alternatives. Under NEPA, the severity and context of an impact must be characterized. An environmental document prepared to comply with CEQA must identify the potentially significant environmental impacts of a proposed project and a reasonable range of alternatives, if required. A “[s]ignificant effect on the environment” means “a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project” (State CEQA Guidelines, Section 15382). CEQA also requires that the environmental document propose feasible measures to avoid or substantially reduce significant environmental impacts (State CEQA Guidelines, Section 15126.4(a)).

The following significance criteria were developed based on guidance provided by the State CEQA Guidelines, and consider the context and intensity of the environmental impacts as required under NEPA. Impacts of an alternative on geology, geologic hazards, geomorphology, mineral resources, and soils would be significant under CEQA if project implementation would do any of the following:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, or injury, or death involving the following:
    - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the

    area or based on other substantial evidence of a known fault

    - Strong seismic ground shaking
    - Seismic-related ground failure, including liquefaction
    - Landslides

- Result in substantial soil erosion or loss of topsoil
- Locate project facilities on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse
- Locate project facilities on expansive soil, as defined in Table 18-1-B of the Uniform Building Code, creating substantial risks to life or property
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for disposal of wastewater
- Result in the loss or availability of known mineral resources that would be of future value to the region and the State

Significance statements are relative to both existing conditions (2005) and future conditions (2030), unless stated otherwise.

Topics Eliminated from Further Discussion

The potential impacts of the project on geologic resources would occur within the primary and extended study areas. Within the extended study area, impacts to geology and soils would occur within the vicinity of the San Joaquin River from Friant Dam to the Merced River confluence, but would not extend downstream or to the CVP and SWP water service areas. The action alternatives would have the greatest effect on conditions within the extended study area along the San Joaquin River from Friant Dam to the Merced River confluence, where the changes in flows due to the project would be greatest. Downstream from the Merced River confluence, inflows from the Merced River and other downstream tributaries would dampen the relative contribution of the action alternatives such that geology and soils would not be substantially affected. The indirect impacts of changes in water deliveries in the CVP and SWP water service areas are mostly within canal systems and any effects on geology and soils would be unlikely and too speculative for meaningful consideration. Therefore, the extended study area beyond the San Joaquin River from Friant Dam to the Merced River confluence is eliminated from further consideration. See Chapter 14, "Hydrology – Surface Water Supplies and Facilities Operations," for a discussion of the direct impacts of the action alternatives in this portion of the extended study area.

Subsidence occurring within the Study Area would be largely due to aquifer compaction caused by pumping-related reduction of groundwater levels; the potential for the project to affect subsidence is therefore addressed in Chapter 13, "Hydrology – Groundwater." Subsidence occurring within the Study Area would also be due to compaction and disappearance of soils with high organic content due to land development; as the project would not influence this mechanism, subsidence is not further discussed in this chapter.

Geologic hazards associated with volcanic activity are not addressed, because there are few volcanoes within the extended study area and none within the primary study area. Paleontological resources are addressed in Chapter 19, "Paleontology."

Direct and Indirect Effects

The following section describes the potential environmental consequences of the alternatives. Where the action alternatives would have identical or nearly identical impacts regardless of which action alternative is implemented, the action alternatives are described together. Where impacts would differ, the action alternatives are described separately.

Impact GEO-1: Exposure of Structures and People to Geologic Hazards Resulting from Seismic Conditions and Slope Instability

Primary Study Area

No Action Alternative No new construction would occur in the primary study area under the No Action Alternative, and the operations of Millerton Lake would change only to increase releases to the San Joaquin River under the SJRRP. Variation in reservoir levels of Millerton Lake due to reoperating Friant Dam under the SJRRP could result in erosion of soils and loss of soil horizons down to bedrock along the reservoir shore in the zone of water elevation variation (SJRRP 2012). Geologic hazards and associated risks to people and structures in this area would remain unchanged from those described in the Affected Environment section of this chapter.

There would be **no impact** under the No Action Alternative.

Action Alternatives Implementing any of the action alternatives would have the potential to increase the exposure of structures and people to geologic hazards. No major faults or shear zones have been identified in the primary study area, historic seismicity rates are low in the vicinity of the proposed Temperance Flat RM 274 Reservoir (Reclamation 2002b), and no active faults have been identified within the primary study area. Because there is minimal seismic activity in the primary study area, the risks of earthquakes, ground shaking, or liquefaction would also be minimal. Areas of known slope instability have been avoided in locating the proposed project features, minimizing the risk of landslides that could expose structures or people to the risk of landslides.

Under all action alternatives, quarry, batch plant, and haul road option C could involve construction of a haul road across a debris flow with slopes of 30-70 percent (see Figure 11-2). Construction and use of roads on this formation could reduce the stability of this formation, increasing the risk of landslide. Standard construction practices (i.e., use of mesh net or other stabilizer on exposed cuts, adequate sizing of road width, etc.) would minimize the risk to construction workers associated with landslides. The area, owned by BLM and leased for grazing, contains no infrastructure or facilities (See Chapter 17, “Land Use Planning and Agricultural Resources”) aside from the San Joaquin River Trail, which would be closed before construction of the haul road, and ultimately relocated. Therefore no additional people or structures would be placed at risk.

Under all action alternatives, Temperance Flat RM 274 Reservoir would inundate 227 acres of mapped debris flows. Inundation of bedrock and soils resulting from the increased pool elevation, and earthwork and vegetation removal associated with new construction, could reduce the stability of hill slopes prone to mass wasting, and mass wasting features may become less stable. However, any landslides that could develop would likely be below the waterline of Temperance Flat RM 274 Reservoir, and would not pose a risk to structures or people.

Temperance Flat RM 274 Reservoir and the immediate area could be subjected to reservoir triggered seismicity (RTS). The International Committee on Large Dams (ICOLD 2011), in their draft document, *Reservoirs and Seismicity – State of Knowledge*, accepted RTS as the most adequate term to describe the phenomena of earthquakes occurring in the vicinity of man-made water reservoirs. The two principal triggers of RTS are added weight stresses and pore pressure propagation. Compared with known cases of RTS at 28 reservoirs around the world, the volume, depth, geological conditions, and seismic conditions present at the proposed Temperance Flat RM 274 Reservoir site suggest that the reservoir would have the potential to trigger a seismic event (Baecher and Keeney 1982). Overall, potential seismic hazard potential at the site is low (Reclamation 2009). Construction of Temperance Flat RM 274 Dam and associated weight stresses and pore pressure propagation would not increase seismic hazard potential at the site (ICOLD 2011), and would therefore not trigger a seismic event greater than those the dam would be designed to withstand. However, other structures within the primary study area could be at risk in the event of RTS, either directly through seismic ground shaking or seiche. The risk of seismic ground shaking is low in most of the San Joaquin Valley and Sierra Nevada foothills (CSSC 2003).

The risk of seiche, a standing wave cause by seismic waves from an earthquake, in Millerton Lake or the proposed Temperance Flat RM 274 Reservoir due to RTS is low. A seiche was recorded in Millerton Lake after a large earthquake in Alaska in 1964; the seiche reached a height of 0.03 feet and lasted 100 minutes (Stanley 1968). The low magnitude and infrequent occurrence of seiches in Millerton Lake can likely be attributed to the geologic and seismic conditions present at the site (McGarr and Vorhis 1968). Similar conditions including a lack of unconsolidated sediments are present at the Temperance Flat Reservoir Area, and therefore the risk of seiche in the proposed Temperance Flat RM 274 Reservoir is considered minimal.

This impact would be **potentially significant** under the action alternatives. Mitigation for this impact is proposed below in the Mitigation Measures section.

Extended Study Area

No Action Alternative Under the No Action Alternative, construction and maintenance activities under the SJRRP would occur along the San Joaquin River from Friant Dam to the Merced River confluence. Flows in the San Joaquin River would increase under the SJRRP, but no other appreciable changes to water supply operations would occur (SJRRP 2012). Geologic hazards and associated risks to people and structures in this area would remain unchanged from those described in the Affected Environment section of this chapter.

There would be **no impact** under the No Action Alternative.

Action Alternatives No new construction would occur in the extended study area under any of the action alternatives, beyond that described for the No Action Alternative. Flows in the San Joaquin River would increase as described in Chapter 14, “Surface Water Supplies and Facilities Operations,” but would not exceed the channel capacity. Geologic hazards and associated risks to people and structures in this area would remain unchanged from those described under the No Action Alternative.

There would be **no impact** under the action alternatives. Mitigation for this impact is not needed and thus not proposed.

Impact GEO-2: Alteration of Fluvial Geomorphology that would Adversely Affect Aquatic Habitat

Primary Study Area

No Action Alternative Under the No Action Alternative, Temperance Flat RM 274 Reservoir would not be constructed. The annual fluctuation in water surface elevation of Millerton Lake would not change, or would change minimally due to changes in releases to the San Joaquin River under the SJRRP. Therefore, there would be no change to streams tributary to the proposed Temperance Flat RM 274 Reservoir or Millerton Lake, or to the San Joaquin River upstream from Millerton Lake.

There would be **no impact** under the No Action Alternative.

Action Alternatives Under all the action alternatives, stream channel equilibrium and geomorphology would be affected by the formation of Temperance Flat RM 274 Reservoir. Streams entering the San Joaquin River upstream from Millerton Lake in the inundation area of the proposed Temperance Flat RM 274 Reservoir would form deltas (roughly triangular-shaped sediment deposits), while streams tributary to Millerton Lake in the inundation area of the proposed Temperance Flat RM 274 Reservoir would experience a change in the location of delta formation. At full pool, the San Joaquin River itself would be inundated up to Kerckhoff Reservoir.

During future operations of Temperance Flat RM 274 Reservoir, when the reservoir was high and regional flooding occurred, sediment transported from the uplands would be deposited as deltas at the confluence of the streams and lake. When the lake level was low, stream channels within the inundation zone would likely be channelized as they downcut into the delta deposits. Because most of the tributary streams are ephemeral or intermittent, the opportunity for sediment transport and delta formation would be highest during sustained rainy periods, such as occur most often during the winter months. The largest stream that would be inundated is Big Sandy Creek in the Temperance Flat area, with 3,431 feet (5.6 percent) inundated. Of the inundated length, 400 feet (11.7 percent) has a gradient of 3 percent or less, and would be prone to delta formation. Given the low sediment carrying capacity of small, ephemeral and intermittent streams, this effect would be minimal.

The proposed Temperance Flat RM 274 Reservoir would also inundate the San Joaquin River up to Kerckhoff Dam, up to 46,488 feet in length. At the top of active storage, the reservoir would reach to about 12 feet below the crest of Kerckhoff Dam. Though most sediment would be captured and stored by upstream reservoirs (see Table 11-3), some sediment would enter the San Joaquin River from Kerckhoff Dam and would be conveyed downstream to the confluence with Millerton Lake, primarily during normal maintenance activities to flush sediment from the reservoir, or during high-flow events during sustained rainy periods when the river’s sediment load would be greatest. Given the complete or near-complete inundation of the San Joaquin River in this reach, this would be substantial.

This impact would be **potentially significant** under the action alternatives. No feasible avoidance or minimization measures are available to reduce this impact below the level of significance. Mitigation for this impact is not proposed because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Extended Study Area

No Action Alternative Under the No Action Alternative, flow releases from Friant Dam to the San Joaquin River would increase under the SJRRP in most cases, while the frequency, volume, and duration of high-flow events would decrease. This could increase downstream channel erosion and change downstream geomorphic characteristics. However, water releases from the dam would continue to vary within their historical range, based on time of year, water year type, and system conditions, as modified by climate change in the extended future (see Chapter 8, “Climate Change”). Channel construction under the No Action Alternative as part of the SJRRP would alter the river channel in several reaches, including construction of a bypass channel around Mendota Pool. These actions are designed to improve the geomorphology and hydrology of aquatic habitats for targeted species.

This impact would be **less than significant** under the No Action Alternative.

Action Alternatives The action alternatives would affect the flow regime in the San Joaquin River and potentially several other reservoirs and downstream waterways. Alterations to river flows could potentially change downstream erosion and geomorphologic characteristics. However, it is expected that the frequency, volume, and duration of high-flow events resulting from the action alternatives would be reduced as compared to existing conditions with current operations. Therefore, downstream erosion would not be anticipated to increase.

This impact would be **less than significant** under the action alternatives. Mitigation for this impact is not needed and thus not proposed.

Impact GEO-3: Loss or Diminished Availability of Known Mineral Resources that Would Be of Future Value to the Region or the State

Primary Study Area

No Action Alternative Under the No Action Alternative, Temperance Flat RM 274 Reservoir would not be constructed. The annual fluctuation in water surface elevation of Millerton Lake would not change, or would change minimally due to changes in releases to the San Joaquin River under the SJRRP (SJRRP 2012). Therefore, there would be no loss or diminished availability of known mineral resources that would be of future value to the region.

There would be **no impact** under the No Action Alternative.

Action Alternatives Approximately 7 million tons of aggregate, including cement, concrete sand and aggregate, and coarse aggregate, would be needed under all action alternatives. The action alternatives would also require approximately 5.3 million cubic yards of embankment material/fill. These materials (with the exception of cement) would be locally sourced from one of the potential aggregate quarries shown in Figure 11-2. Aggregate materials are produced locally along the San Joaquin River downstream from Friant Dam, and south along the Kings River. The quantity of aggregate that would be needed under any action alternative would be less than 1 percent of the total quantity available locally (see the Affected Environment section of this chapter), and would not substantially reduce local mapped aggregate resources.

A survey conducted in 2003 by BLM in support of the Investigation identified three abandoned mine sites within the primary study area, including the Patterson Mine, San Joaquin Mine, and the Sullivan Mine Group (Springer 2005). These sites are small deposits with no known activity, and are therefore likely to be of little value to the region or State (USGS 2005).

This impact would be **less than significant** under the action alternatives. Mitigation for this impact is not needed and thus not proposed.

Extended Study Area

No Action Alternative Under the No Action Alternative, implementation of the SJRRP would result in variation in San Joaquin River levels due to reoperating Friant Dam, which could result in inundation of existing gravel and sand mining locations. As described in the SJRRP PEIS/R (SJRRP 2012), reoperating Friant Dam to release Restoration Flows could change the timing, frequency, and duration of fluctuations in the water level of the San Joaquin River. However, release of Restoration Flows would fall within the historical range of reservoir releases, and attendant river-level fluctuations would be within the historical range of fluctuations, as modified by climate change in the extended future (see Chapter 8, “Climate Change”). SJRRP construction activities could result in short-term alteration of existing gravel or sand mining locations, but would not result in long-term interruption of mining activities. The No Action Alternative would not alter the use of these existing gravel or sand mining locations.

There would be **no impact** under the No Action Alternative.

Action Alternatives Flows in the San Joaquin River would increase as described in Chapter 14, "Hydrology – Surface Water Supplies and Facilities Operations," but would not exceed channel capacity. The release of additional water from Friant Dam to the San Joaquin River under the action alternatives would fall within the historical range of reservoir releases, and attendant river-level fluctuations would be within the historical range of fluctuations from flood management releases, as modified by climate change in the extended future (see Chapter 8, "Climate Change"). No new construction beyond that described under the No Action Alternative would occur in the extended study area under any of the action alternatives and no gravel and sand extraction locations would be affected by the action alternatives.

This impact would be **less than significant** under the action alternatives. Mitigation for this impact is not needed and thus not proposed.

Impact GEO-4: Substantial Soil Erosion or Loss of Topsoil Due to Construction and Operations

Primary Study Area

No Action Alternative Under the No Action Alternative, Temperance Flat RM 274 Reservoir would not be constructed. Variation in reservoir levels of Millerton Lake due to reoperating Friant Dam under the SJRRP could result in erosion of soils and loss of soil horizons down to bedrock along the reservoir shore in the zone of water elevation variation (SJRRP 2012).

There would be **no impact** under the No Action Alternative.

Action Alternatives Construction-related erosion of topsoil would occur within the primary study area, but would be minimized through implementation of the erosion and sediment control plans and stormwater pollution prevention plans that are a part of the environmental commitments common to all action alternatives, as described in Chapter 2, "Alternatives." Once Temperance Flat RM 274 Dam was constructed and the reservoir filled, shoreline erosion would occur along the zone of reservoir-elevation fluctuation. Substantial soil erosion and loss of topsoil would result.

Construction of Temperance Flat RM 274 Dam, powerhouse, batch plant, and transmission facilities would require the excavation, transport, stockpiling, grading, drilling, blasting, and use of bedrock, alluvium, and soil obtained from the aggregate quarry (see Figure 11-2). Other activities would include the demolition and removal of existing facilities within the inundation zone, installation of support structures, construction of permanent access roads and temporary haul roads, and use of staging areas. Soils disturbed by these activities, as well as materials stockpiled for use during construction, would be susceptible to the effects of wind- or water-induced erosion and loss of topsoil.

Construction-related erosion would be avoided and/or minimized via implementation of the erosion and sediment control plans and stormwater pollution prevention plans (i.e., erosion and sediment control plans, including site revegetation) that are a part of the environmental commitments common to all action alternatives. These plans would address the necessary local jurisdiction requirements regarding erosion control and site revegetation, and would implement BMPs for erosion and sediment control. The plans would include site-specific structural and operational BMPs to prevent and control short- and long-term erosion and sedimentation effects, stabilize soils and vegetation in areas affected by construction activities, and prevent and control impacts on runoff quality. Types of BMPs to be included in the plans could include, but would not be limited to, earth dikes and drainage swales, stream bank stabilization, silt fencing, sediment basins, fiber rolls, sandbag barriers, straw bale barriers, storm drain inlet protection, hydraulic mulch, and stabilized construction entrances.

Once Temperance Flat RM 274 Dam was constructed and the reservoir filled, shoreline erosion would occur along the zone of reservoir-elevation fluctuation between the top-of-active-storage capacity (1,331 TAF) and the top-of-minimum-carryover-storage capacity (200 TAF under Alternative Plans 1, 2, and 3; 325 TAF under Alternative Plan 4; and 100 TAF under Alternative Plan 5). Substantial soil erosion and loss of topsoil would occur in the area of shoreline subject to fluctuating water levels.

Water surface elevations in Temperance Flat RM 274 Reservoir could fluctuate between the top-of-active-storage capacity and the top-of-minimum-carryover-storage capacity within a single year. This area comprises about 4,300 acres under Alterative Plans 1, 2, and 3; about 3,700 acres under Alternative Plan 4; and about 5,000 acres under Alternative Plan 5. The actual fluctuation in any single year is a function of the starting storage for that year, the inflow, and the operational diversions and releases and is limited, but not driven, by the maximum physical fluctuation potential. The maximum theoretical fluctuation of Temperance Flat RM 274 Reservoir in any action alternative is in Alternative Plan 5, and is 382 feet. From the CalSim II operations modeling, Temperance Flat RM 274 Reservoir elevation reached the maximum theoretical fluctuation in a single year of the 83 year simulation period once under each action alternative under existing conditions, and did not reach the maximum theoretical fluctuation under future conditions. The simulated fluctuation under Alternative Plan 5 is below 300 feet in about 96 percent of the years, and below 245 feet in about 90 percent of the years, with an average annual fluctuation of about 150 feet.

Sediment delivery into the reservoir resulting from shoreline erosion would be retained within the reservoir. The rate of shoreline erosion would be greatest during the first several years after construction, and would reduce over time as the new shoreline stabilizes. Much of the topography in the general vicinity of the proposed Temperance Flat RM 274 Reservoir is steep, increasing susceptibility to erosion, particularly the first several miles downstream from Kerckhoff Dam and along the north side of Millerton Lake just upstream from RM 274.

This impact would be **potentially significant** under the action alternatives. All feasible avoidance and minimization measures have been included in the project commitments, but would not reduce this impact below the level of significance. Mitigation for this impact is not proposed because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Extended Study Area

No Action Alternative Under the No Action Alternative, implementation of the SJRRP would result in variation in San Joaquin River levels due to reoperating Friant Dam, which could increase downstream channel erosion. Reoperating Friant Dam to release full Restoration flows when downstream channel capacity permits, including a reduction in the timing, frequency, duration, and volume of flood releases (as described in Chapter 12, “Hydrology – Flood Management”), would change the timing, frequency, duration, and volume of flows in the San Joaquin River and bypasses, and could change rates of stream channel erosion and meander migration. However, the overall rates of erosion and sedimentation would remain similar to those under existing conditions (SJRRP 2012).

This impact would be **less than significant** under the No Action Alternative.

Action Alternatives Under the five action alternatives, operation of the proposed Temperance Flat RM 274 Reservoir and Millerton Lake would change the timing, frequency, duration, and volume of flows in the San Joaquin River and bypasses, and could change rates of stream channel erosion and meander migration. Flows within the San Joaquin River would remain within the range of historical flows, while the number of flood releases from Friant Dam would be reduced (as described in Chapter 12, "Hydrology – Flood Management"), as modified by climate change in the extended future (see Chapter 8, "Climate Change"). Therefore, downstream erosion would not be anticipated to increase.

The action alternatives would reduce the frequency, magnitude, and duration of Friant Dam releases greater than Restoration Flows. This in turn would reduce the potential for riparian zone/bank erosion, the rate of unmanaged migration of gravel from spawning areas (potentially reducing the required rate of gravel augmentation), and the rate of downstream unmanaged sand migration (potentially reducing the rate/frequency of required sand removal at flow control structures).

This impact would be **less than significant** under the action alternatives. Mitigation for this impact is not needed and thus not proposed.

Impact GEO-5: Failure of Septic Tanks or Alternative Wastewater Disposal Systems Due to Soils that Are Unsuited to Land Application of Waste

Primary Study Area

No Action Alternative Under the No Action Alternative, Temperance Flat RM 274 Reservoir would not be constructed. The annual fluctuation in water surface elevation of Millerton Lake would not change, or would change minimally due to changes in releases to the San Joaquin River under the SJRRP. Therefore, there would be no increase in the risk of failure of septic tanks or alternative wastewater disposal systems.

There would be **no impact** under the No Action Alternative.

Action Alternatives In general, soils in the primary study area are poorly suited to use as septic tank leach fields or alternative waste disposal systems due to shallow soil depth, high rock content, and excessive slope. Under the action alternatives, relocated wastewater facilities associated with new or relocated facilities, such as recreational facilities and maintenance buildings, would be designed and constructed to satisfy the conditions of sewage disposal permits issued by Fresno County or Madera County, as applicable. Existing septic facilities within the inundation area that would not be relocated would be demolished according to regulatory requirements.

This impact would be **less than significant** under the action alternatives. Mitigation for this impact is not needed and thus not proposed.

Extended Study Area

No Action Alternative Under the No Action Alternative, no septic tanks or wastewater disposal systems would be constructed in the extended study area. Therefore, there would be no increase in the risk of failure of septic tanks or alternative wastewater disposal systems.

There would be **no impact** under the No Action Alternative.

Action Alternatives Under the action alternatives, no septic tanks or wastewater disposal systems would be constructed in the extended study area. Therefore, there would be no increase in the risk of failure of septic tanks or alternative wastewater disposal systems.

There would be **no impact** under the action alternatives. Mitigation for this impact is not needed and thus not proposed.

Mitigation Measures

This section discusses mitigation measures for each significant impact described in the environmental consequences section, as presented in Table 11-8.

No mitigation is required for Impacts GEO-3 and GEO-5 within the primary study area, or for Impacts GEO-1, GEO-2, GEO-3, GEO-4, and GEO-5 within the extended study area, as these impacts would be **less than significant** for all action alternatives.

Impacts GEO-1, GEO-2 and GEO-4 within the primary study area would be potentially significant. Mitigation measure

GEO-1, below, is proposed to reduce the effects of Impact GEO-1. Feasible measures to reduce effects of GEO-2 and GEO-4 have been designed into the action alternatives. No feasible mitigation measures are available at the time of preparation of this Draft EIS to reduce Impacts GEO-2 and GEO-4 to less-than-significant levels. Therefore, Impacts GEO-2 and GEO-4 (within the primary study area) would be **potentially significant and unavoidable**.

Mitigation Measure GEO-1: Develop and Implement a Seismic Action Plan

Reclamation will develop and implement a Seismic Action Plan to monitor and analyze seismic activity at Temperance Flat RM 274 Dam and Reservoir, and take action to minimize risks associated with potential RTS. Specifically, monitoring and analyses will include:

- Monitor seismicity in the vicinity of Temperance Flat RM 274 Reservoir before, during, and after construction

- Analyze pre and post-impoundment seismicity on a regular basis, including examination of spatial and seismicity rate patterns in light of RTS cases observed worldwide

- Analyze seismicity variations associated with changes in filling and drawdown rates, once reservoir operations begin

If a seismic hazard associated with RTS is identified, Reclamation will take actions to minimize the risk to structures and people. Specific actions will depend on the risks identified, and will be outlined in the plan, but may include emergency notifications to the public, reinforcements of structures, and/or temporary closure of public facilities such as recreational facilities.

The seismic risk of the region is low, and implementation of the Seismic Action Plan would minimize risk of RTS. Implementation of this mitigation measure would reduce Impact GEO-1 to a **less-than-significant** level.

This page left blank intentionally.

Chapter 12
Hydrology – Flood Management

This chapter describes the environmental setting for flood management, including flood-related structures and operations, as well as potential environmental consequences and associated mitigation measures, as they pertain to implementing the alternatives. It focuses on the primary study area (area of project features, Temperance Flat Reservoir Area, and Millerton Lake below RM 247). It also discusses the extended study area (San Joaquin River from Friant Dam to the Merced River, the San Joaquin River from the Merced River to the Delta, the Delta, and the CVP and SWP service areas).

Affected Environment

This section describes the affected environment related to flood protection history in the San Joaquin River Basin, flood management structures, State Plan of Flood Control (SPFC) levees (also referred to as project levees), nonproject levees, and flood management operations and conditions.

Historical Perspective of Flood Management in the San Joaquin River Basin

Early Flood Management

Flood management in the San Joaquin River Basin began with the construction of levees to reclaim fertile tule lands and to protect agriculture from seasonal out-of-bank flows. Private levee systems were developed incrementally to protect individual tracts of land; this practice would often redirect floodwater elsewhere, thereby increasing flood stage and risk. The protection afforded by individual levee segments would also decrease because of the increased stage, and the flood protection provided varied widely due to the intermittent and irregular nature of the levees. The increased flood danger led to competition between landowners who continually raised and strengthened their levees to maintain or increase flood protection to their lands.

In 1920, Colonel Robert Marshall, chief geographer for the USGS, proposed a major water storage and conveyance plan to transfer water from Northern California to meet urban and agricultural needs of Central and Southern California. This plan ultimately provided the framework for development of the CVP and its associated flood damage reduction benefits. Under the Marshall Plan, a dam would be constructed on the San Joaquin River near Friant to divert water north and south to areas in the eastern portion of the San Joaquin River Basin, and provide flood protection to downstream areas. The diverted water would be a supplemental supply to relieve some of the dependency on groundwater that had led to overdraft in areas of the eastern San Joaquin Valley. Water from the Sacramento Valley would be collected, stored, and transferred to the San Joaquin Valley by a series of reservoirs, pumps, and canals.

In 1933, the California State Legislature approved the Central Valley Project Act, which authorized construction of initial features of the CVP, including Shasta Dam; Friant Dam; power transmission facilities from Shasta to Tracy; and the DMC and Contra Costa, Madera, and Friant-Kern canals. The act authorized the sale of revenue bonds to construct the project, but during the Great Depression, the bonds could not be sold. The State appealed to the Federal government for assistance in constructing the CVP.

With the passage of the Rivers and Harbors Act of 1935, Congress appropriated funds and authorized construction of the CVP by the USACE. When the act was reauthorized in 1937, construction and operation of the CVP were assigned to Reclamation, and the project became subject to Reclamation Law. Construction of the CVP began on October 19, 1937, with the Contra Costa Canal. Construction of Shasta Dam began in 1938 and was completed for full operation in 1949. Friant Dam, on the San Joaquin River, was also completed in 1949.

Subsequent to and concurrent with the construction of the CVP, various other flood management facilities in the San Joaquin River Drainage Basin were constructed. These included various reservoirs with dedicated or incidental flood management benefits; a flood bypass system along the San Joaquin River; and various levees and control structures. Some of these facilities remain locally maintained and operated, while others were formally adopted into the State-Federal flood control system (the SPFC).

Major Recent Floods

Between 1900 and 1997, the Sacramento and San Joaquin river basins experienced 13 destructive floods. Each flood resulted from a storm with unique characteristics, each located in a different portion of the Central Valley. In addition, these floods occurred under different levels of development of the flood management systems described in the previous sections. The most recent floods (1983, 1986, 1995, and 1997) caused extensive damage in both the Sacramento and San Joaquin river basins and raised questions about the adequacy of the current flood management systems and land use in the floodplains (USACE 1999). In response to these floods, Congress authorized USACE in 1997 to undertake a comprehensive study of the flood damage reduction facilities in the Sacramento and San Joaquin river basins, and to prepare a summary of recent flood events (USACE 1999). The following flood event descriptions are drawn from this previous documentation (USACE 1999).

Flood of 1955 The December 1955 flood was centered north of Friant Dam, and was more intense in the northern portions of the San Joaquin Valley and in the Sacramento Valley. Before the start of the flood, Millerton Lake was well below flood management space and, as a result, flows on the San Joaquin River were completely controlled by Friant Dam. If storage had been at or above the allowable flood management level, releases from Friant Dam would have exceeded 37,100 cfs and would have resulted in extensive damage between Friant Dam and the mouth of the Merced River. A peak flow of 62,500 cfs was a record on the Stanislaus River at Ripon, while the Middle Fork of the Tuolumne River at Oakland Recreation Camp reached a record flow of 4,920 cfs. During the 1955 floods, two of the three forks of the Tuolumne River also reached record flows (USACE 1999).

Flood of 1967 Above-normal precipitation that occurred continuously from December 1966 through March 1967 resulted in the flooding of 35,000 acres of the San Joaquin River Basin. A record-breaking storm in early December 1966 resulted in very high runoff from the San Joaquin River. The San Joaquin River above Millerton Lake experienced high runoff during early December with a maximum mean daily inflow of 18,450 cfs to the lake. A vast snowmelt from April to July resulted in significant flood damage from flooding in the lower portions of the Fresno and Chowchilla rivers. Nearly all of the flooded areas were cropland, improved pasture, or grazing land (USACE 1999).

Flood of 1983 Northern and Central California experienced moderate flooding incidents from November through March because of numerous storms. In early May, snow water content in the Sierra Nevada exceeded 230 percent of normal, and the ensuing runoff resulted in approximately four times the average volume for Central Valley streams. The maximum daily flow on the San Joaquin River at Maze Road Bridge was about 38,400 cfs, and exceeded the estimated channel capacity (combined capacity of the San Joaquin River and Laird Slough) of 26,000 cfs. In the San Joaquin River Basin, levee breaks caused flooding at four locations along the San Joaquin River. Four levees failed in the Delta, resulting in partial or total flooding of some islands. Estimated damages exceeded $324 million in the San Joaquin River Basin (USACE 1999).

Flood of 1986 Flooding in 1986 resulted from a series of four storms over a 9-day period during February. Rains from the first three storms saturated the ground and produced moderate-to-heavy runoff before the arrival of the fourth storm. Peak daily inflow to Millerton Lake was about 20,800 cfs, with the storm taking up all up 16 percent of available flood control space. In the San Joaquin River Basin and the Delta, levee breaks along the Mokelumne River caused flooding in the community of Thornton and the inundation of four Delta islands. Estimated damages exceeded $15 million in the San Joaquin River Basin (USACE 1999).

Flood of 1995 Weather conditions in the Pacific forced major storm systems directly into California during much of the winter and early spring of 1995. The largest storm systems hit California in early January and early March. The major brunt of the January storms hit the Sacramento River Basin and resulted in small stream flooding primarily because of storm drainage system failures. The March 1995 storms were concentrated on the Coast Ranges, and caused high flows in some west-side tributaries to the San Joaquin River Basin. In particular, Arroyo Pasajero produced extremely high flows that collapsed bridges on Interstate 5 near Coalinga, killing six people. Peak daily inflow to Millerton Lake was about 23,700 cfs. At the time of the peak event, Millerton Lake had only 4 percent of its flood control space available. In total, estimated flood damages in 1995 exceeded $193 million in the San Joaquin River Basin (USACE 1999).

Flood of 1997 Watersheds in the Sierra Nevada had experience heavy snowfall and already were saturated by the time three subtropical storms added more than 30 inches of rain in late December 1996 and early January 1997. The third and most severe of these storms lasted from December 31, 1996, through January 2, 1997. Record flows overwhelmed the flood management system in the San Joaquin River Basin. Peak daily inflow to Millerton Lake was about 51,800 cfs, with a peak hourly inflow of about 95,000 cfs as Millerton Lake exceeded its design capacity. Peak daily outflows to the San Joaquin River from Friant Dam were estimated at 37,500 cfs, with a peak hourly outflow of 62,900 cfs. Thirty-four levee failures occurred throughout the river system and widespread flooding ensued. The Delta also experienced several levee breaks and levee overtopping. Estimated damages exceeded $223 million in the San Joaquin River Basin (USACE 1999).

Flood of 2006 During late December 2005 and early January 2006, several storms caused substantial runoff over large portions of Northern California. Local flooding caused Federal disaster declarations in 10 counties and an estimated $300 million in damages, with most damage occurring in the Russian and Napa river basins (USGS 2006). Wet weather persisted through the late winter and early spring. Another large storm system hit California in early April, with the San Joaquin Valley receiving most of the precipitation. This storm system caused several days of high water in the San Joaquin River and associated flood bypass system. Stress was evident in the levee system, including boils and bank erosion. Active flood fighting limited the flood damage to mostly local agricultural lands, although several trailer parks and low-lying homes were evacuated (NWS 2010). The wet 2006 winter, including the April storm, resulted in high snowmelt runoff volumes, and several weeks of sustained flood released from Millerton Lake. These releases peaked at 9,000 cfs. This period of high, sustained flows highlighted several vulnerabilities of the San Joaquin River levee system to such flows.

Flood Management Structures

The following is a description of flood management structures in the Study Area. This section focuses on the dams and bypasses on the San Joaquin River upstream from its confluence with the Merced River. A description of levees within the Study Area is located in the Levees section of the Affected Environment section.

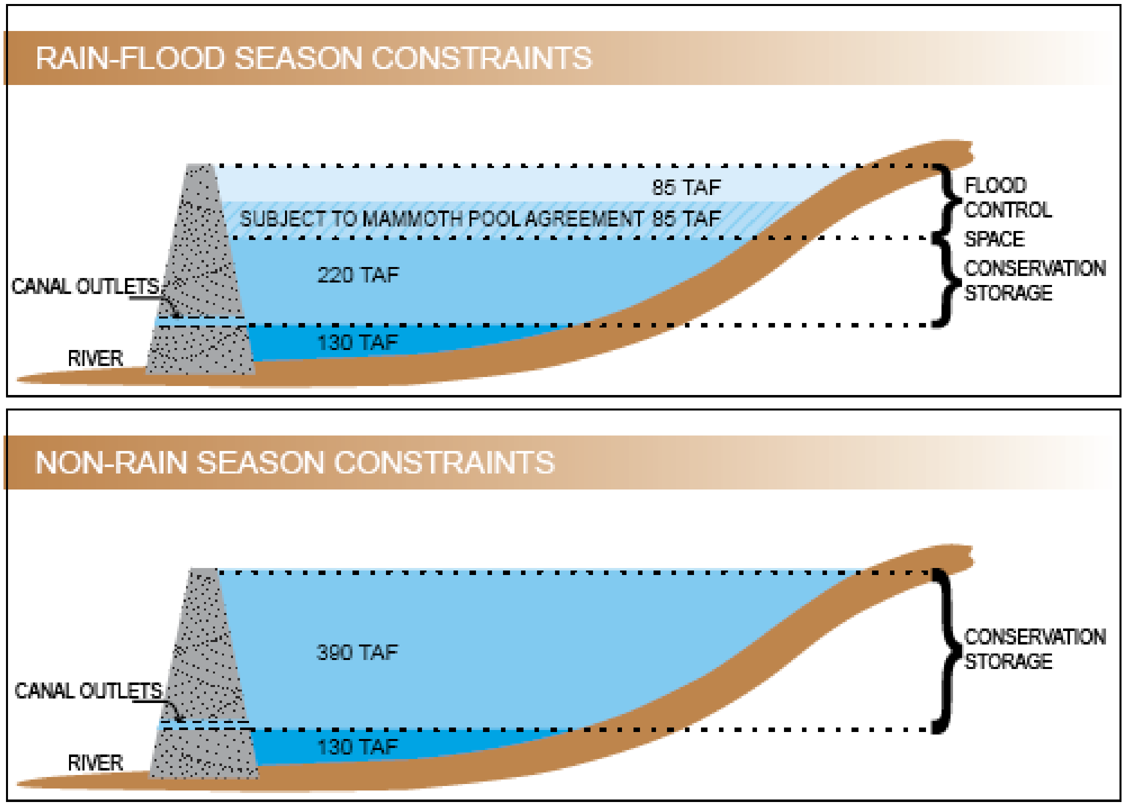
Primary Study Area

This section describes the flood management structures located in the primary study area, including the Temperance Flat Reservoir Area and Millerton Lake below RM 274.

Temperance Flat Reservoir Area Upstream from the site of the proposed Temperance Flat RM 274 Dam, the Southern California Edison Company (SCE) operates six major storage reservoirs, providing an aggregate storage space of 560 TAF. These reservoirs are: Florence Lake, Huntington Lake, Mammoth Pool, Shaver Lake, Redinger Lake, and Lake Thomas A. Edison. PG&E operates Bass Lake in Crane Valley, which provides an additional 45 TAF of storage. These reservoirs operate in conjunction with various diversion structures that convey water to 14 hydroelectric power plants above Friant Dam. The combined storage of these reservoirs provides significant storage during snowmelt and rainfall events (USACE 1955). Kerckhoff Reservoir and Dam, a 4 TAF power generation dam is immediately upstream from the proposed Temperance Flat RM 274 Reservoir, but provides no significant additional flood control space.

Millerton Lake Below RM 274 Friant Dam is the principal flood damage reduction facility on the San Joaquin River. It is a concrete gravity structure with dual purposes of storage for irrigation and flood management. Millerton Lake has a volume of 524 TAF, a surface area of 4,905 acres, and an elevation of 580.6 feet above msl (North American Vertical Datum 1988 [NAVD 1988]) at gross pool (Reclamation 2008). The spillway flood pool elevation is 587.6 feet. This elevation was almost reached during the January 1997 flood, when the maximum observed water surface elevation was 583 feet. The reservoir has three small dikes along the reservoir rim to close low-lying areas off from Millerton Lake. Millerton Road, a two-lane paved secondary highway, passes over these dikes. Additional physical information pertaining to Friant Dam and Millerton Lake are presented in Chapter 14, “Hydrology – Surface Water Supplies and Facilities Operations.”

The minimum operating storage of Millerton Lake is 130 TAF, resulting in active available conservation storage of about 390 TAF (Figure 12-1). The minimum operating storage allows for diversion from dam outlets to the Friant-Kern Canal (elevation 466.6 feet), Madera Canal (elevation 448.6 feet), and the San Joaquin River (elevation 382.6 feet) (Reclamation 2008). The flood management reservation of 170 TAF is required to be maintained during the rain-flood season (October–April), but can be reduced down to 85 TAF based on available storage in Mammoth Pool.



Source: Reclamation 2005.
Key:
TAF = thousand acre-feet

Figure 12-1. Conceptual Representation of Millerton Lake Storage Requirements

Extended Study Area

This section describes the flood management structures, including dams, levees, and bypass systems, within the extended study area.

San Joaquin River from Friant Dam to Merced River The State constructed the Lower San Joaquin River Flood Control Project, which includes bypasses, control structures, and other facilities within the extended study area (Figure 12-2). Construction of these State facilities was initiated in 1959 and completed in 1966. These improvements were coordinated with the Federal government’s Lower San Joaquin River and Tributaries Project (LSJRTP) to improve the effectiveness of the Federal portion of the project; the LSJRTP includes levee and channel improvements downstream from the Merced River confluence and was completed in 1968.

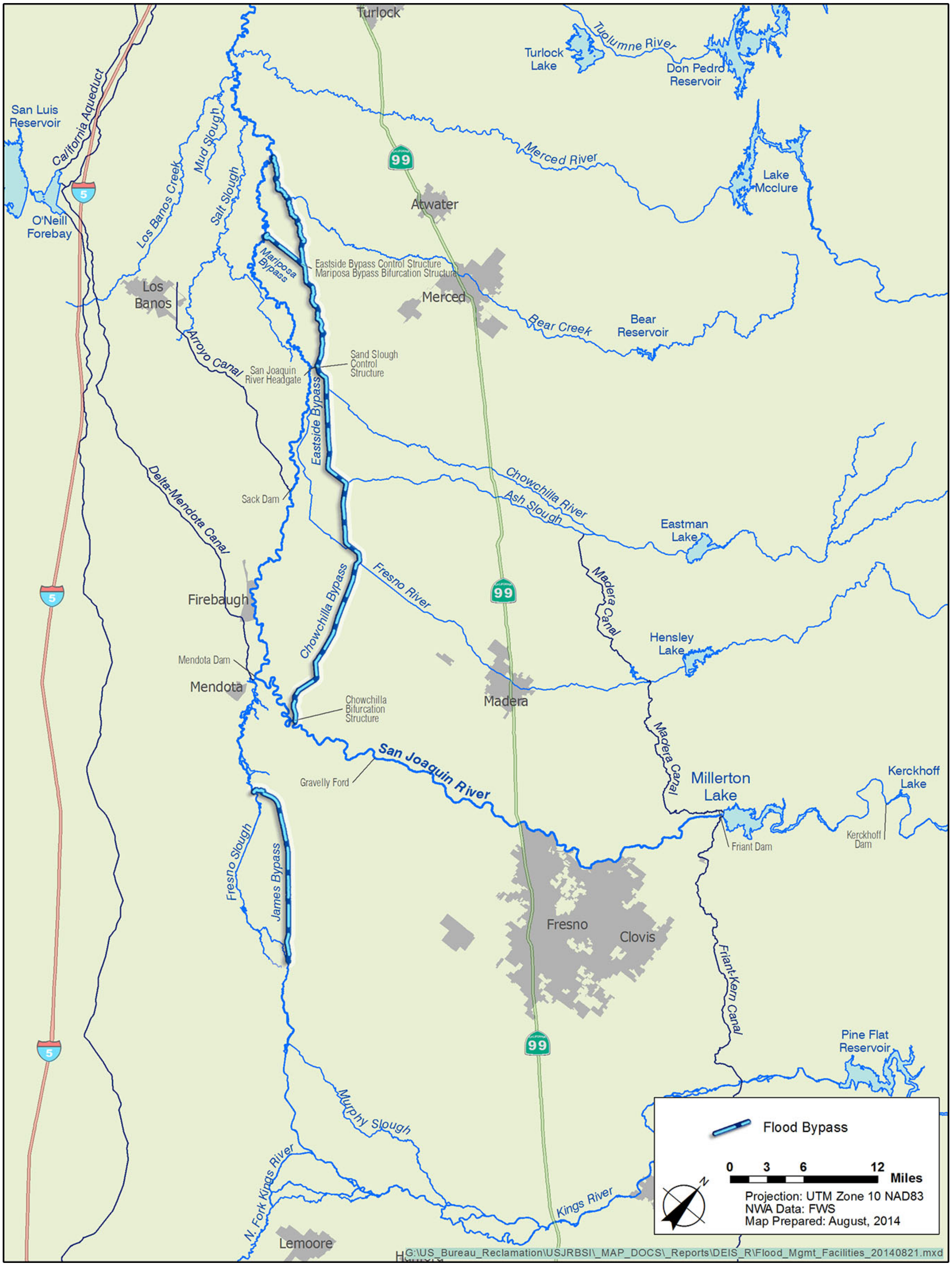


Figure 12-2. Existing Flood Bypass Facilities in the San Joaquin River Basin

The Lower San Joaquin River Flood Control Project is primarily a bypass system that consists of human-made channels (Eastside, Chowchilla, and Mariposa bypasses), which divert and carry flood flows from the San Joaquin River downstream from Gravelly Ford, along with inflows from the Kings River and other tributaries, downstream to the main stem San Joaquin River just above the Merced River confluence. The system consists of approximately 193 miles of levees, several control structures, and other appurtenant facilities. O&M of the State's completed upstream bypass features are performed by the Lower San Joaquin Levee District (LSJLD). The flood damage reduction structures and facilities within the extended study area are described below. Levees are described separately in a subsequent section.

Chowchilla Bypass and Chowchilla Bypass Bifurcation Structure The 5,500 cfs capacity Chowchilla Bypass begins at the Chowchilla Bypass Bifurcation Structure on the San Joaquin River. It runs northwest, parallel to the San Joaquin River, to its confluence with the Fresno River, where the Chowchilla Bypass ends and becomes the Eastside Bypass. The Chowchilla Bypass Bifurcation Structure is a gated structure that controls the proportion of flood flows that remain in the San Joaquin River between the Chowchilla Bypass and the Mendota Canal. The LSJLD O&M Manual provides for the Chowchilla Bypass Bifurcation Structure to be operated to keep flows on this portion of the San Joaquin River at a level less than 2,500 cfs because of channel capacity limitations (LSJLD 1978). Significant seepage has been observed at flows above 1,300 cfs and therefore current operations generally limit flow in this section of the San Joaquin River to 1,300 cfs (RMC 2007).

Eastside Bypass and Eastside Bypass Control Structure The Eastside Bypass extends from the confluence of the Fresno River and the Chowchilla Bypass to its confluence with the San Joaquin River, approximately 19.5 miles west of Merced at DWR RM 135.5. The Eastside Bypass gradually increases in design channel capacity from 10,000 cfs to 17,000 cfs between its start at the Fresno River and the Sand Slough Control Structure; this is because the bypass receives additional flows from the Fresno River, Berenda Slough, and Ash Slough. The bypass design channel capacity is 16,500 cfs between the Sand Slough Control Structure and the Eastside Bypass Bifurcation Structure. The Eastside Bypass then continues northwest and joins with Bear Creek and continues to its confluence with the San Joaquin River. The Eastside Bypass has a design channel capacity of 13,500 cfs downstream from the Eastside Bypass Bifurcation Structure, and a design channel capacity of 18,500 cfs downstream from its confluence with Bear Creek. In addition to receiving flows from the San Joaquin River, this reach of the Eastside Bypass also receives flows from Bear, Deadman, and Owens creeks before joining the San Joaquin River (Reclamation 2009b).

The gated Eastside Bypass Control Structure works in coordination with the Mariposa Bypass Bifurcation Structure to direct flows to the most downstream reach of the Eastside Bypass or to the Mariposa Bypass. The channel capacities described above are design capacities; current capacities may be reduced because of subsidence of Eastside Bypass levees, including a cumulative subsidence of approximately 4.5 feet along the Eastside Bypass over the last 5 years due to changes in groundwater use (SLCC 2013).

Sand Slough Control Structure/San Joaquin River Headgates
The Sand Slough Control Structure, located in the short connection between the San Joaquin River at DWR RM 168.5 and the Eastside Bypass, is an uncontrolled weir working in coordination with the San Joaquin River Headgates to control the flow split between the main stem San Joaquin River and the Eastside Bypass. The Sand Slough Control Structure diverts flows from the San Joaquin River to the Eastside Bypass, and the San Joaquin River Headgates control the timing and quantity of flows continuing to pass through the San Joaquin River. The operating rule for the control structure and headgates is to divert the first 50 cfs of San Joaquin River flow to Sand Slough, and then equally divide flow in excess of 50 cfs to Sand Slough and the San Joaquin River. Historical operations have kept the headgates closed, diverting all flows to Sand Slough (RMC 2007).

Mariposa Bypass and Mariposa Bypass Bifurcation Structure
The Mariposa Bypass Bifurcation Structure controls the proportion of flood flows that continue down the Eastside Bypass or return to the San Joaquin River just south of the San Luis National Wildlife Refuge East Bear Creek Unit through the Mariposa Bypass. The Mariposa Bypass delivers flow from the Eastside Bypass back into the San Joaquin River. Of the 14 bays on the Mariposa Bypass Bifurcation Structure, 8 are gated. The operating rule for the Mariposa Bypass is to divert all flows to the San Joaquin River when flows in the Eastside Bypass above the Mariposa Bypass are less than 8,500 cfs, with flows greater than 8,500 cfs remaining in the Eastside

Bypass, eventually discharging back into the San Joaquin River at the Bear Creek confluence. However, flows of up to 3,000 cfs have historically remained in the Eastside Bypass, and approximately one-quarter to one-third of the additional flows were released to the Mariposa Bypass (McBain and Trush 2002). Flood flows not diverted to the San Joaquin River via the Mariposa Bypass continue down the Eastside Bypass and are returned to the San Joaquin River via Bravel Slough and Bear Creek. Bravel Slough reenters the San Joaquin River at the ending point of the bypass system.

Mendota Dam Mendota Dam is located at the confluence of the San Joaquin River and Fresno Slough. Fresno Slough connects the Kings River to the San Joaquin River. Fresno Slough delivers water to the south from Mendota Pool during irrigation season, and delivers water to the Mendota Pool and San Joaquin River from the Kings River when the Kings River is flooding. Mendota Pool is a small reservoir, with approximately 8,500 acre-feet of storage, created by the 23-foot-high Mendota Dam (Reclamation 2004). The Mendota Pool does not provide any appreciable flood storage. The water surface elevation in the pool is maintained by a set of gates and flashboards that are manually opened or removed in advance of high-flow conditions. This process lowers the water level in the pool for passing high flows to reduce seepage impacts on adjacent lands, but prevents diversions on Fresno Slough from the DMC and San Joaquin River flows.

Cyclically, the Mendota Pool fills with sediment during infrequent high-flow releases from Friant Dam. During times of high flows, some unknown portion of this sediment is able to flush and route downstream when flashboards have been pulled, restoring much of the Mendota Pool storage capacity. If the flashboards are not pulled before a high-flow event from either the San Joaquin River or Fresno Slough, the increased water surface elevations cause seepage problems on upstream and adjacent properties.

Sack Dam Sack Dam is 5-foot-high low-head structure used to divert water from the San Joaquin River into Arroyo Canal. Diversions to Arroyo canal are usually limited to 600 cfs, but range from 0 to 800 cfs (Reclamation 2009b). Recently, changes in groundwater use are causing subsidence between the Eastside Bypass and the San Joaquin River. The San Luis Canal Company (SLCC) reports recent subsidence of Sack Dam at rates exceeding 0.5 foot per year (SLCC 2013). Both Central California Irrigation District (CCID) and SLCC are working with growers in the western portion of Madera County to develop potential solutions to subsidence in those areas that directly impact Sack Dam and other physical infrastructure (Exchange Contractors 2013, CCID 2012).

Structures on the Kings River Flood flows from the Kings River flow via the James Bypass and Fresno Slough into the Mendota Pool and San Joaquin River at their confluence with Fresno Slough. As a result, Kings River system operations influence operations on the San Joaquin River. Flood control facilities on the Kings River include the following:

- **James Bypass –** The James Bypass is a leveed channel beginning in the lower Kings River Basin at the end of the Kings River North, and running northwest to end at Fresno Slough. Fresno Slough transports overflows from the Kings River via the James Bypass to the Mendota Pool. Excess water in the Mendota Pool overflows into the San Joaquin River. The broad flood channels of Kings River North are farmed in the spring, and property owners are notified when flood releases are planned to be sent north so that farm equipment may be removed. Flows from the Kings River are controlled by Pine Flat Dam. Maximum flows in the James Bypass/Fresno Slough typically range from 4,750 cfs to 6,000 cfs (USACE 1993).

- **Pine Flat Dam –** Pine Flat Dam, completed in 1954, is owned, operated, and maintained by USACE. The dam is on the Kings River, about 28 miles northeast of Fresno, and provides flood protection to 200,000 acres of agricultural land in the Tulare Lake area. Pine Flat Dam is a 429-foot-high, 1,820-foot-long concrete gravity dam with a storage capacity of 1,000 TAF and a flood management reservation of 475 TAF. The major goal of flood operations at Pine Flat Dam, and its objective release of 4,750 cfs below the Crescent Weir, is to prevent flooding of farmland along over 100 miles of the Kings River (in the Tulare Lake bed) and along the San Joaquin River.

- **Army Weir –** The Army Weir, constructed in 1943, controls the flow split between Kings River South (south to the Tulare Lake bed) and Kings River North (north to the San Joaquin River). Although constructed by, and under the jurisdiction of, USACE, permission was granted to the Kings River Water Association to operate the structure according to agreements among the water users. The association operates the weir to maximize flow north into the San Joaquin River up to a total of 4,750 cfs to partially relieve flooding within the Tulare Lake bed to the south. When flows exceed 4,750 cfs, the excess, up to 1,200 cfs, is diverted to the south. All flows over 5,950 cfs are sent north until maximum diversions at the Crescent Weir are reached.

- **Crescent Weir –** The Crescent Weir, downstream from the Army Weir, began operation on Kings River North in 1939; it is maintained and operated by the Crescent Canal Company under an agreement with the Zalda Reclamation District. The concrete weir has 18 openings and uses flashboards for flow control. The Zalda Reclamation District controls flows greater than 4,750 cfs at the Crescent Weir by sending the first 4,750 cfs north, and the excess, up to a maximum of 2,000 cfs, south. Flows greater than 7,950 cfs in the Kings River North (4,750 cfs north, 1,200 cfs south from the Army Weir, and 2,000 cfs south from the Crescent Weir) are divided by the Army and Crescent weirs equally between north and south, respectively, with consideration of existing levee and channel conditions.

Structures on Other Major San Joaquin River Tributaries Upstream from Merced River Each major tributary to the San Joaquin River has existing flood control facilities, including the following:

- **Hidden Dam and Hensley Lake –** Hidden Dam, completed in 1975, is on the Fresno River about 15 miles northeast of the City of Madera, and is owned, operated, and maintained by USACE. It provides flood protection to the City of Madera and agricultural lands downstream. Hidden Dam has a storage capacity of 90 TAF, a flood management reservation of 65 TAF, and an objective release of 5,000 cfs at the Merced River and Madera Canal confluence. Hensley Lake is formed by the 163-foot-high, 5,730-foot-long earthfill dam.

- **Buchanan Dam and H. V. Eastman Lake –** Buchanan Dam, completed in 1975, is owned, operated, and maintained by USACE to provide flood protection to the City of Chowchilla and the highly developed agricultural areas below the dam. The project is on the

Chowchilla River about 16 miles northeast of the City of Chowchilla. The Buchanan Dam is a 206-foot-high, 1,800-foot-long rockfill dam and has a storage capacity of 150 TAF, a 45 TAF flood management reservation, and a combined downstream objective release of 7,000 cfs via Ash (5,000 cfs) and Berenda (2,000 cfs) sloughs.

- **Redbank and Fancher Creeks Flood Control Project** – The Redbank and Fancher Creeks Flood Control Project is owned and operated by the Fresno Metropolitan Flood Control District. This is a single-purpose project that provides flood protection to the Fresno-Clovis metropolitan area and nearby agricultural land. This project has a storage capacity of approximately 42 TAF and includes five facilities: (1) Big Dry Creek Dam and Diversion, (2) Alluvial Drain Detention Basin, (3) Fancher Creek Dam and Reservoir, (4) Pup Creek Detention Basin, and (5) Redbank Creek Detention Basin.

- **Los Banos Detention Dam –** Los Banos Detention Dam, completed in 1965, is a joint CVP/SWP dam located on Los Banos Creek, a westside tributary to the San Joaquin River. This dam provides flood protection to the San Luis Canal and DMC, the community of Los Banos, and the agricultural lands downstream. Los Banos Detention Dam on Los Banos Creek has a storage capacity of 34.6 TAF and a flood management reservation of 14 TAF to control flows to a maximum of 1,000 cfs at Los Banos (USACE 1999).

- **Merced County Stream Group Project –** The Merced County Stream Group Project, with a combined storage capacity of approximately 41 TAF, consists of five dry dams (Bear, Burns, Owens, Mariposa, and Castle) located in the foothills east of Merced on tributaries to the San Joaquin River. These provide flood protection to the City of Merced. USACE owns and maintains the first four dams. Castle Reservoir is owned by the State and Merced County, and is operated and maintained by the Merced ID. The project objective is to restrict the flood flows of several streams in the Merced County Stream Group to the nondamaging capacity of the valley floor channels, from the foothill line to the City of Merced. This project also includes two diversion structures (Black Rascal Creek to Bear Creek

Diversion, and the Owens Creek to Mariposa Creek Diversion).

San Joaquin River from Merced River to the Delta Flood management facilities on major tributaries that affect flood conditions in the San Joaquin River from the confluence with the Merced River to the Delta include the following:

- **Paradise Cut** Paradise Cut is a channel with a rock weir on its upstream end at the San Joaquin River and a design capacity of 15,000 cfs that is a “shortcut” between the San Joaquin River and Old River. SPFC levees border both sides of Paradise Cut, with right-bank levees maintained by Reclamation District (RD) 2062 and RD 2107 and providing flood protection for Steward Tract and Lathrop. Left bank levees are maintained by RD 2058 and RD 2095. As part of the CVFMP, DWR is evaluating the expansion of Paradise Cut to reduce flood stages on the San Joaquin River between Mossdale and Stockton, thereby reducing the probability of flooding in Lathrop, Manteca, and other communities in unincorporated San Joaquin County.

- **New Exchequer Dam and Lake McClure** New Exchequer Dam is on the Merced River about 25 miles northeast of the City of Merced. The dam has a top-of-active-storage capacity of 1,024 TAF, a maximum flood management reservation of 350 TAF, and a downstream objective release of 6,000 cfs in the Merced River at Stevinson. The dam, completed in 1966, is a 1,220-foot-long, 490-foot-high rockfill structure, with a 1,500-foot-long, 62-foot-high rock-and-earthfill dike. The dam and lake, which are owned, operated, and maintained by the Merced ID, provide flood protection to agricultural lands below the dam and to the communities of Livingston, Snelling, Cressy, and Atwater.

- **New Don Pedro Dam and Lake** Don Pedro Dam is on the Tuolumne River, about 28 miles west of Modesto. The dam has a top-of-active-storage capacity of 2,030 TAF, a maximum flood management reservation of 340 TAF, and an objective release of 9,000 cfs below Dry Creek. The dam was constructed in 1971 jointly by Turlock ID and Modesto ID with participation by the City and County of San Francisco for water supply, hydropower, and flood control purposes. However, only Turlock ID operates and maintains the dam. Don Pedro Dam is an earth and rockfill structure 580 feet high and 1,900 feet long. This dam provides flood management for agricultural property, infrastructure, and some low areas in suburban Modesto by controlling rain and snowmelt floods.

- **New Melones Dam and Lake** New Melones Dam replaced the original Melones Dam, and was completed by USACE in 1978 and approved to begin operation in 1983. The dam is on the Stanislaus River, 35 miles northeast of Modesto, and is operated as part of the CVP for water supply, hydropower, flood control, water quality, and environmental purposes. The dam has a top-of-active-storage capacity of 2,420 TAF, a maximum flood management reservation of 450 TAF, and a downstream objective release of 8,000 cfs or less at Orange Blossom Bridge in the Stanislaus River. New Melones Dam and Lake are owned, operated, and maintained by Reclamation as a unit of the CVP. The dam is an earth and rockfill structure 625 feet high and 1,560 feet long. New Melones Lake flood management protects more than 35,000 acres of leveed agricultural land, infrastructure, and some limited urban areas in Oakdale, Riverbank, and Ripon along the Stanislaus and San Joaquin rivers (USACE 1980).

Delta Flood management facilities within and adjacent to the Delta are present on Littlejohns Creek, Calaveras River and Mormon Slough, and the Mokelumne River, as described below.

Littlejohns Creek Farmington Reservoir on Littlejohns Creek is owned and operated by USACE to restrict downstream flood flows to nondamaging levels throughout the network of channels along the lower reaches of Littlejohns and Rock creeks. The reservoir has the capacity to temporarily store up to 52 TAF of floodwater. The project also includes a diversion channel from Duck Creek to Littlejohns Creek, channel improvement work on selected streams, cutoff dikes, and a small diversion dam to confine flood flows to the main channel of Littlejohns Creek. By reducing flows to the downstream objective release of 2,000 cfs, Farmington Dam provides flood protection to 58,000 acres of intensely developed agricultural lands below the dam, the City of Stockton, and the rural towns of Farmington and French Camp.

A dike across Duck Creek and a 5,000-foot-long diversion channel divert Duck Creek flow to Littlejohns Creek. The channel has a design capacity of 500 cfs. South Littlejohns Creek has a 2.3-mile-long right-bank levee in two segments and a 2.6-mile-long left-bank levee. The project is intended to reduce flood risk to Stockton and its surrounding urban area.

Calaveras River and Mormon Slough The Calaveras River enters the San Joaquin River near the City of Stockton. With a design capacity of 13,500 cfs, the Calaveras River receives nearly all of its flow from rainfall.

The major water management facility on the Calaveras River, New Hogan Dam and Reservoir, is operated for flood management and, if possible, for M&I water supply, irrigation, recreation, and power generation purposes. New Hogan Dam and Reservoir are owned and operated by USACE; the reservoir has a total storage capacity of 317.1 TAF and a flood management reservation of 165 TAF. The dam is constructed of rock-and-earthfill, and is 200 feet high and 1,960 feet long, with four earthfill dikes with a total crest length of 1,355 feet.

Flood management operations at New Hogan Dam and Reservoir protect about 46,000 acres of agricultural land and 14,000 acres of urban and suburban land along the Calaveras River, Mormon Slough, and the Stockton Diverting Canal. The reservoir provides protection to Stockton and the smaller cities of Linden, Waterloo, and Bellota. New Hogan Reservoir is operated to meet an objective release of 12,500 cfs downstream in Mormon Slough.

There are additional flood management facilities within the Calaveras River drainage. These include facilities of the Mormon Slough Project, which consist of a diversion from Mormon Slough, and pumping plants. The Mormon Slough Project is maintained by the San Joaquin County Flood Control and Water Conservation District. Mormon Slough diverts irrigation and higher flows from the Calaveras River at Bellota Weir and has a design capacity of 12,500 cfs.

Mokelumne River The Mokelumne River enters the lower San Joaquin River northwest of Stockton, in the Delta at Bouldin Island. On the Mokelumne River are two reservoirs, Pardee and Camanche, which are both owned and operated by East Bay Municipal Utility District (EBMUD).

Pardee Reservoir has a storage capacity of 210 TAF and is operated for water supply, power, and recreation. Downstream, Camanche Reservoir has a total storage capacity of 430.9 TAF and a maximum flood management reservation of 200 TAF. Camanche Reservoir is operated for flood management, downstream fishery needs, irrigation, hydroelectric power generation, and recreation. It provides flood protection to the lower Mokelumne River Basin—Lodi, Woodbridge, Thornton, and 69,000 acres of agricultural land—by maintaining river flows to the downstream objective release of 5,000 cfs.

Camanche Dam is operated in conjunction with Pardee Dam and Reservoir (EBMUD), and Salt Springs and Lower Bear reservoirs (PG&E), all located upstream from Camanche Dam. The required flood management reservation can be exchanged between Camanche and Pardee reservoirs.

CVP and SWP Service Areas The CVP and SWP services areas relevant to the action alternatives do not contain flood management structures that would be influenced by the action alternatives.

Levees

This section describes the leveed system on the San Joaquin River from Friant Dam to its confluence with the Merced River.

Primary Study Area

There are currently no levees in the primary study area.

Temperance Flat Reservoir Area There are no levees existing or planned around the proposed Temperance Flat RM 274 Reservoir.

Millerton Lake Below RM 274 There are no levees existing or planned around Millerton Lake.

Extended Study Area

There are two classes of levees along the San Joaquin River and associated flood bypass channels:

- **Project levees** – Levees constructed by USACE as part of the Lower San Joaquin River Flood Control Project and LSJRTP. These are SPFC levees for which the State has accepted responsibility for operations and maintenance.

- **Nonproject levees** – Levees constructed by individual landowners to protect site-specific properties, and thus not associated with SPFC. These levees are typically associated with levees and dikes constructed on the San Joaquin River by early flood control districts and adjacent landowners.

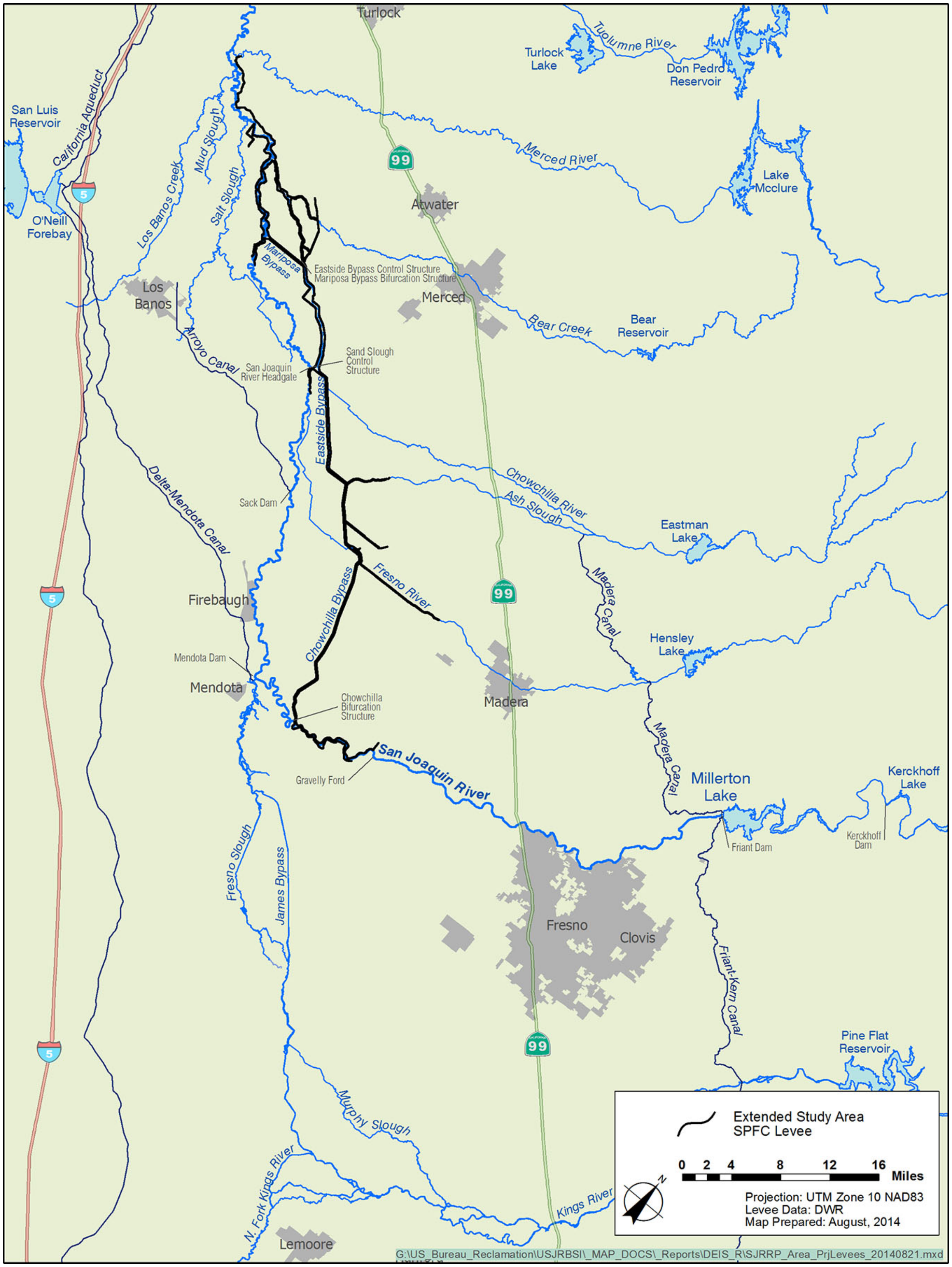
San Joaquin River from Friant Dam to Merced River
Levees in this reach form a parallel conveyance system that includes the following:

- A leveed bypass system on the east side of the San Joaquin River

- A leveed flow conveyance system along the main stem of the San Joaquin River

The main stem San Joaquin River levee system within the extended study area is composed of approximately 192 miles of project levees and various nonproject levees located upstream from the San Joaquin and Merced rivers confluence (see Figure 12-3 for the locations of project levees). Levees vary widely with respect to geometry (height and width) and construction.

Project levees occur on the San Joaquin River between Gravelly Ford and the Chowchilla Bypass Bifurcation Structure. Project levees also occur along the Chowchilla, Eastside, and Mariposa bypasses. A small section of project levees are present on the San Joaquin River upstream from Sand Slough, contiguous with project levees on the bypasses. Project levees begin again just upstream from the San Joaquin River and Mariposa Bypass confluence, contiguous with project levees on the bypasses, and continue downstream to the confluence of the Merced and San Joaquin rivers.



G:\US_Bureau_Reclamation\USJRBSI_MAP_DOCS_Reports\DEIS_R\SJRRP_Area_PrjLevees_20140821.mxd

Figure 12-3. Project Levees along the San Joaquin River and Bypasses from Friant Dam to the Confluence with Merced River

Nonproject levees line the San Joaquin River between the Chowchilla Bypass Bifurcation Structure and the Mariposa Bypass confluence. Canal embankments bordering both sides of the San Joaquin River between Mendota Dam and approximately 2 miles upstream from the Sand Slough Control Structure effectively form a set of nonproject levees that have significantly reduced the width of the floodplain. The existing San Joaquin River channel capacity in this reach is approximately 4,500 cfs, but flows of this magnitude can cause seepage and threaten levee stability (RMC 2007). High, sustained flows during the 2006 snowmelt runoff period highlighted this capacity issue. Recent changes in groundwater use have contributed to subsidence, and may have further reduced the channel capacity in this reach (SLCC 2013). In addition, local landowners have constructed other low-elevation berms within the reach creating a narrower floodplain.

San Joaquin River from Merced River to the Delta From about 1956 to 1972, the USACE constructed the LSJRTP from the Delta upstream to the confluence of the San Joaquin and Merced rivers, under the authorization of the Flood Control Act of 1944. Additional modifications to the LSJRTP were completed in the mid-1980s. The federally constructed portion of the LSJRTP consists of about 100 miles of intermittent levees along the San Joaquin River, Paradise Cut, Old River, and the lower Stanislaus River. These levees vary in height from about 15 feet at the downstream end to an average of 6 to 8 feet over much of the project. The levees, along with upstream flow regulation, were designed to contain floods occurring, on average, once every 60 years at the lower end of the project to floods occurring, on average, once every 100 years at the upper limits. Local levees are located along many reaches of the river in the gaps between the LSJRTP levees.

Delta Levee protection within the Delta consists of levees along eastside Delta tributaries and levees surrounding Delta islands.

A combination of project and nonproject levees protects lands adjacent to Littlejohns and Duck creeks, the Calaveras River, and Mormon Slough. Project levees protect the City of Stockton from flood flows on the Calaveras River and Mormon Slough, and project levees on Littlejohns Creek protect French Camp just south of Stockton. On Bear Creek, project levees provide flood protection for agricultural lands and north Stockton.

In the Delta, about 65 major islands containing 538,000 acres of farmland, homes, and other structures, are protected from riverine and tidal waters by 1,100 miles of levees. A few small islands lack levees and a series of currently present open water areas were formerly islands. Most original Delta levees were built with dredged soils from nearby channels and generally provide low levels of flood protection for adjacent lands. Most levees were not engineered and have been locally built and maintained. Levees along the Delta waterways are nonproject levees, with the exception of some levees in the north Delta along the Sacramento River and along the San Joaquin River near Stockton.

CVP and SWP Service Areas There are no existing or planned levees within the CVP and SWP service areas that would be affected by the project.

Flood Management Operations and Conditions

The following sections contain information about flood management operations in the Study Area.

Primary Study Area

This section details the flood management operations in the Temperance Flat Reservoir Area and Millerton Lake below RM 274. It includes a brief description of the Temperance Flat Reservoir Area and current operational constraints on Friant Dam.

Area of Project Features Currently, a flood control operations manual has not been written for the proposed Temperance Flat RM 274 Dam. Expected flood reduction benefits are discussed below in the Temperance Flat Reservoir Area section.

Temperance Flat Reservoir Area The five action alternatives do not include additional dedicated flood storage capacity upstream from Friant Dam. Under each action alternative, the flood space requirement of 170 TAF would generally be maintained in Millerton Lake (operated in conjunction with Mammoth Pool). Temperance Flat RM 274 Reservoir could provide significant additional flood storage space if needed in very wet years, as the larger total storage volume increases the probability that the total storage in Millerton Lake and Temperance Flat RM 274 Reservoir would be less than the regulatory flood control limit.

Millerton Lake Below RM 274 Friant Dam and Millerton Lake are operated for flood management in accordance with rules and regulations prescribed by CFR Title 33 Part 208.11, the Field Working Agreement for CVP dams and reservoirs, and the Flood Control Manual for Friant Dam. Since the writing of the Flood Control Manual, operations at Friant Dam have been modified to include releases of Restoration Flows to meet flow targets at Gravelly Ford as part of the SJRRP (Reclamation 2006). Pursuant to the SJRRP's Restoration Flows Guidelines, Restoration Flows are not released in addition to flood flows and, generally, flood flows satisfy required flow targets (Reclamation 2013b). The Flood Control Manual states the following flood management objectives for Friant Dam and Millerton Lake (USACE 1955):

- Control the sum of flows from Friant Dam without exceeding 8,000 cfs below Cottonwood Creek and Little Dry Creek, or 6,500 cfs at the USGS gaging station "San Joaquin River near Mendota."

- Permit use of the maximum practical amount of storage space for conservation and other purposes without impairing the flood control functions.

According to the Flood Control Manual, flood management operation is determined daily, as described in the Flood Control Diagram (Chart A-11 of Flood Control Manual), which prescribes the required flood control space in Millerton Lake and gives the schedule for releasing water from the flood management space (Figure 12-1). Two types of flood management space and their characteristics are summarized as follows:

- **Rain flood space** – This space increases from zero on October 1 to 170 TAF on November 1, and decreases from 170 TAF on February 1 to 0 TAF on April 1. Water stored in rain flood space during this period is released as rapidly as possible without violating the flood management objective release. The Mammoth Pool Agreement allows for rain flood space in excess of 85 TAF to be replaced by an equal amount of space in Mammoth Pool from November 1 to February 1, if available. Mammoth Pool is a 123 TAF reservoir upstream from Millerton Lake.

- **Conditional space** – This space is required from February 1 to June 30 to help manage snowmelt runoff.

> This variable space is predicated on filling the reservoir (if possible) by the end of the snowmelt season without exceeding downstream design flows. The required conditional space and supplemental releases on a given date are determined from the Flood Control Diagram. This diagram uses the following data: forecasted unimpaired runoff into Millerton Lake, amount of upstream storage available, and forecasted irrigation demand from that date to June 15 (after May 31, demand is estimated as forecasted irrigation demand for the next 15 days, or until August, whichever is less). Snowmelt runoff credit may be given to all reservoirs upstream from Friant Dam. This space is equal to the total space available in the upstream reservoirs minus the adjustments to upstream space given in Chart A-11 of the Flood Control Manual.

Use of the 170 TAF flood management reservation, as directed by the Flood Control Manual, provides for an objective release of 8,000 cfs. Downstream flow changes are limited to 500 cfs per hour for the safety of recreational users along the river, and to minimize damage to riverbanks from sloughing and erosion (USACE 1999). Flows at Friant Dam must be adjusted to account for flow entering the river below the dam so as not to exceed the 8,000 cfs design capacity.

Extended Study Area

San Joaquin River from Friant Dam to Merced River The design capacities for the various San Joaquin River reaches are given in Table 12-1. Design capacity was authorized as the amount of water that can pass through a given reach with a levee freeboard of 3 feet within the historical San Joaquin River and 4 feet of freeboard along the bypasses (except along the left side of the Eastside Bypass, which has 3 feet of design freeboard) (USACE 1993). Design capacities are generally considered to be safe carrying capacities, although some flood damages to adjacent land developments can occur when design flows are passed (USACE 1993). Seepage under and through levees, and backwatering of local storm drainage systems, can damage adjacent lands. Levee subsidence and sediment accumulation in various reaches has decreased channel capacities, increasing damage risk.

Table 12-1. Design Capacities of San Joaquin River and Bypasses

River/ Waterway	Upstream Extent	Downstream Extent	Levee Type	Design Capacity[1] (cfs)
San Joaquin River	Friant Dam	State Route 99	None	8,000
San Joaquin River	State Route 99	Gravelly Ford	None	8,000
San Joaquin River	Gravelly Ford	Chowchilla Bypass Bifurcation Structure	Project	8,000
San Joaquin River	Chowchilla Bypass Bifurcation Structure	Mendota Dam	Nonproject	2,500
San Joaquin River	Mendota Dam	Sack Dam	Nonproject	4,500
San Joaquin River	Sack Dam	Sand Slough Control Structure	Nonproject	4,500
San Joaquin River	Sand Slough Control Structure	Confluence with Mariposa Bypass	Nonproject	1,500
San Joaquin River	Confluence with Mariposa Bypass	Confluence with Bear Creek and Eastside Bypass	Project	10,000
San Joaquin River	Confluence with Bear Creek and Eastside Bypass	Confluence with Merced River	Project	26,000
Chowchilla Bypass	Chowchilla Bypass Bifurcation Structure	Confluence with Fresno River and Eastside Bypass	Project	5,500
Eastside Bypass	Fresno River	Sand Slough Bypass	Project	10,000–17,000
Eastside Bypass	Sand Slough Bypass	Mariposa Bypass Bifurcation Structure/Eastside Bypass Bifurcation Structure	Project	16,500
Eastside Bypass	Mariposa Bypass Bifurcation Structure/Eastside Bypass Bifurcation Structure	Confluence with San Joaquin River	Project	13,500–18,500
Sand Slough Bypass	Sand Slough Control Structure	Eastside Bypass	Project	3,000
Mariposa Bypass	Mariposa Bypass Bifurcation Structure	Confluence with San Joaquin River	Project	8,500
Kings River North	Fresno Slough Bypass	Mendota Pool	Nonproject	4,750

Note:
[1] From DWR Flood Channel Design Flows Diagram (DWR 1985).
Key:
cfs = cubic feet per second
Nonproject = not part of the State Plan of Flood Control
Project = State Plan of Flood Control facility

Friant Dam to Gravelly Ford From Friant Dam to Gravelly Ford, flows are predominantly influenced by releases from Friant Dam, and additionally by diversions and seepage losses below State Route 99. This section of the river is incised and there are no project or nonproject levees. Urban surface runoff into this portion of the San Joaquin River is limited because of stormwater management by the Fresno Metropolitan Flood Control District. All but 5 of the District’s 161 drainage basins route stormwater to retention and detention facilities in the Fresno metropolitan area.

Gravelly Ford to Mendota Pool The San Joaquin River continues from Gravelly Ford for approximately 24 miles to the Mendota Pool. This portion marks the end of the incised channel, and the river is a meandering channel of low gradient. The Chowchilla Bypass Bifurcation Structure regulates flow within this portion of the San Joaquin River.

The California State Reclamation Board (1969) guidelines describe how the Lower San Joaquin River Flood Control Project is to be operated on this portion of the San Joaquin River:

- "The first increment of flow down the San Joaquin River may be routed through either the San Joaquin River or the Chowchilla Bypass. Up to 2,500 cfs shall normally be routed through the San Joaquin River insofar as it does not exceed the capacity of the river when added to the releases from Pine Flat Dam and the remaining increment flow" (Reclamation Board 1969). Excess water from the Kings River system, which enters the river through the James Bypass, has priority to available capacity in the San Joaquin River below the Mendota Pool.

- "Up to 5,500 cfs shall be passed through the Chowchilla Bypass Bifurcation Structure. A total flow of 8,000 cfs will normally be divided with up to 2,500 cfs passing through the San Joaquin River Control Structure and 5,500 cfs passing through the Chowchilla Canal Bypass Control Structure" (Reclamation Board 1969).

- "Should the flows exceed 8,000 cfs at the control structures or 10,000 cfs at the latitude of Mendota, the District will operate the control structures at their own discretion with the objective of minimizing damage to the flood control project and protected area" (Reclamation Board 1969). The LSJLD considers the latitude flow of Mendota to be the sum of flows in the San Joaquin River immediately downstream from the Chowchilla Bypass Bifurcation Structure, the James Bypass/Fresno Slough, and the Chowchilla Bypass at the latitude of Mendota.

LSJLD operates the Lower San Joaquin River Flood Control Project for safety purposes, taking into account channel capacity limitations and flows from the San Joaquin River, James Bypass/Fresno Slough, and water supply deliveries to Mendota Pool. When flood flows in the San Joaquin River are between 0 cfs and 8,000 cfs upstream from the Chowchilla Bypass Bifurcation Structure, historical operations typically route up to 1,300 cfs to the San Joaquin River, with the remaining flow going into the Chowchilla Bypass.

Mendota Pool to Sack Dam This portion of the San Joaquin River flows 23 miles along a sandy channel from Mendota Dam to Sack Dam, where flows are diverted to the Arroyo Canal. The design channel capacity is 4,500 cfs. Significant bed lowering has been measured along this reach of the San Joaquin River; however, it is unknown to what extent this bed lowering is because of subsidence from groundwater overdraft, or human-induced sedimentation and hydrology modification within the channel. Kings River flood flows, via the James Bypass/Fresno Slough, also affect instream flow in the San Joaquin River, and have priority to use available conveyance capacity over upstream San Joaquin River flows. During large release events at Friant Dam, upper San Joaquin River flows can be diverted at the Chowchilla Bypass Bifurcation Structure to allow incremental flow from James Bypass into this portion of the San Joaquin River, as described in the Lower San Joaquin River Flood Control Project guidelines (Reclamation Board 1969).

Sack Dam to Sand Slough Control Structure From Sack Dam to the Sand Slough Control Structure, the San Joaquin River has a design capacity of 4,500 cfs.

Sand Slough Control Structure to Mariposa Bypass Between the Sand Slough Control Structure and Mariposa Bypass, the San Joaquin River has a design capacity of 1,500 cfs. The Sand Slough Control Structure is used to maintain this design capacity.

Operations have kept the Sand Slough Control Structure gates closed, diverting all flow to the Eastside Bypass over the last few decades (RMC 2007). Therefore, between the Sack Dam and the Mariposa Bypass, the San Joaquin River is dry until downstream agricultural return flows contribute to its baseflow.

Mariposa Bypass to Eastside Bypass Confluence The San Joaquin River has a design capacity of 10,000 cfs between the Mariposa Bypass and its confluence with the Eastside Bypass. This portion of the river conveys returned tributary and flood flows from the bypass system.

Eastside Bypass Confluence to Merced River Confluence The San Joaquin River extends approximately 18 miles from its confluence with the Eastside Bypass to its confluence with the Merced River. The design channel capacity is 26,000 cfs, and the channel receives flows from the San Joaquin River and Eastside Bypass.

San Joaquin River from Merced River to the Delta In this reach, the three main tributaries of the lower San Joaquin River include the Merced, Tuolumne, and Stanislaus rivers. Dams on the Merced and Tuolumne rivers are both privately owned and operated. New Melones Reservoir, which is owned and operated by Reclamation, regulates the Stanislaus River. Table 12-2 shows USACE design capacities for the San Joaquin River downstream from the Merced River confluence which guide reservoir operations for flood management.

Table 12-2. Design Capacity of Lower San Joaquin River and Tributaries Flood Control Project

San Joaquin River Reach	USACE Design Capacity (cfs)[1]
Merced River to Tuolumne River	45,000
Tuolumne River to Stanislaus River	46,000
Stanislaus River to Paradise Dam (at head of Paradise Cut)	52,000
Paradise Dam to Old River	37,000
Old River to Stockton Deep Water Ship Channel	22,000

Source: California Resources Agency 1976
Notes:
[1] Design capacity includes three feet of freeboard.
Key:
cfs = cubic feet per second
USACE = U.S. Army Corps of Engineers

Delta The Mokelumne and Calaveras rivers, and several eastside tributaries drain to the Delta. USACE dams on the Calaveras River (New Hogan Dam) and Littlejohns Creek (Farmington Dam) provide downstream flood protection. EBMUD dams on the Mokelumne River (Pardee and Camanche dams) provide downstream flood protection to the lower Mokelumne Basin. Because of the lack of flood management structures (such as levees), significant flooding around Stockton has been caused by high flows on the Calaveras River and Bear Creek. Table 12-3 shows the flood channel design flows of the eastside Delta tributaries.

Table 12-3. Flood Channel Design Flows of Eastside Delta Tributaries

River/Creek	Flood Channel Design Flows (cfs)
Littlejohns Creek downstream from Lone Tree Creek Confluence[1]	1,750
Duck Creek[1]	2,000
Mormon Slough upstream from Calaveras Creek Confluence[1]	12,500
Calaveras Creek downstream from Mormon Slough Confluence[1]	13,500
Bear Creek[1]	5,500
Mokelumne River upstream from Cosumnes River Confluence[2]	2,500

[1] *Source: DWR 1985*
[2] *Source: USACE 1997*
Key:
cfs = cubic feet per second

CVP and SWP Service Areas The CVP and SWP pumping facilities near Tracy are not operated for flood management. Also, the CVP and SWP service areas within the extended study area are not operated for flood management and are therefore not described in this section.

Environmental Consequences and Mitigation Measures

This section discusses environmental consequences on the flood management system associated with implementing the alternatives. The potential direct and indirect impacts on the flood management system and associated mitigation measures are summarized in Table 12-4. As shown in the table, the alternatives resulted in either no impact or less-than-significant impacts, requiring no mitigation.

Table 12-4. Summary of Impacts and Mitigation Measures for Flood Management

Impact	Study Area	Alternative	Level of Significance Before Mitigation	Mitigation Measure	Level of Significance After Mitigation
FLD-1: Exposure of People or Structures to a Significant Risk of Loss, Injury or Death Involving Flooding, Including Flooding as a Result of the Failure of a Levee or Dam	Primary Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	LTS		LTS
		Alternative Plan 2	LTS		LTS
		Alternative Plan 3	LTS		LTS
		Alternative Plan 4	LTS		LTS
		Alternative Plan 5	LTS		LTS
	Extended Study Area	No Action Alternative	LTS	None Required	LTS
		Alternative Plan 1	LTS and Beneficial		LTS and Beneficial
		Alternative Plan 2	LTS and Beneficial		LTS and Beneficial
		Alternative Plan 3	LTS and Beneficial		LTS and Beneficial
		Alternative Plan 4	LTS and Beneficial		LTS and Beneficial
		Alternative Plan 5	LTS and Beneficial		LTS and Beneficial
FLD-2: Substantially Alter the Existing Drainage Pattern of the Site or Area, Including through the Alteration of the Course of a Stream or River, or Substantially Increase the Rate or Amount of Surface Runoff in a Manner which would Result in Onsite or Offsite Flooding	Primary Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	LTS		LTS
		Alternative Plan 2	LTS		LTS
		Alternative Plan 3	LTS		LTS
		Alternative Plan 4	LTS		LTS
		Alternative Plan 5	LTS		LTS
	Extended Study Area	No Action Alternative	LTS	None Required	LTS
		Alternative Plan 1	LTS		LTS
		Alternative Plan 2	LTS		LTS
		Alternative Plan 3	LTS		LTS
		Alternative Plan 4	LTS		LTS
		Alternative Plan 5	LTS		LTS
FLD-3: Place Within a 100-Year Flood Hazard Area Structures which would Impede or Redirect Flood Flows	Primary Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	NI		NI
		Alternative Plan 2	NI		NI
		Alternative Plan 3	NI		NI
		Alternative Plan 4	NI		NI
		Alternative Plan 5	NI		NI
	Extended Study Area	No Action Alternative	NI	None Required	NI
		Alternative Plan 1	NI		NI
		Alternative Plan 2	NI		NI
		Alternative Plan 3	NI		NI
		Alternative Plan 4	NI		NI
		Alternative Plan 5	NI		NI

Key: LTS = less than significant NI = no impact

Methods and Assumptions

The total flood storage capacity of the San Joaquin River upstream from Friant Dam was assumed to remain unchanged with the potential construction of Temperance Flat RM 274 Dam and Reservoir. The currently required total available flood control storage and operations rules at Millerton Lake were assumed to apply to the combined storage in Millerton Lake and Temperance Flat RM 274 Reservoir. Consequently, each action alternative would provide the same flood control storage space as under the existing *Friant Dam and Millerton Lake Report on Reservoir Regulation for Flood Control* (USACE 1980); only this space would be shared between the two reservoirs.

Temperance Flat RM 274 Reservoir could provide additional storage space in wet years, as the reservoir would likely not be full and the empty storage could be used to store additional flood flows that would have been released under the No Action Alternative. To quantify the flood reduction benefits of the action alternatives, simulated available monthly storage during wet years in Millerton Lake and Temperance Flat RM 274 Reservoir was extracted from the CalSim II model. For the No Action Alternative, available storage upstream from Friant Dam was assumed to be limited to Millerton Lake. For the action alternatives, available storage upstream from Friant Dam included Millerton Lake and Temperance Flat RM 274 Reservoir.

Flood releases from Friant Dam were also extracted from the CalSim II model for all alternatives and comprise releases required to maintain current flood control space in Millerton Lake and releases made in anticipation of imminent large snowmelt volumes that would be required to maintain flood control space requirements.

Criteria for Determining Significance of Effects

The thresholds of significance for impacts are based on the environmental checklist in Appendix G of the State CEQA Guidelines, as amended. These thresholds also encompass the factors taken into account under NEPA to determine the significance of an action in terms of its context and intensity of its impacts. Impacts on flood management resulting from the alternatives would be significant if the alternatives would cause any of the following:

- Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam
- Substantially increase the rate or amount of surface runoff in a manner that would result in onsite or offsite flooding
- Place housing within a 100-year flood hazard area as mapped on a Federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map
- Place structures that would impede or redirect flood flows within a 100-year flood hazard area

Topics Eliminated from Further Consideration

None of the action alternatives will place housing within a 100-year flood hazard area. This topic was therefore eliminated from further discussion.

Direct and Indirect Effects

This section summarizes the impacts related to flood management in the primary and extended study areas. Within this section, the impacts for Alternative Plans 1 through 5 were evaluated together, as they are expected to have the same impact on flood management in both the primary and extended study areas.

Impact FLD-1: Exposure of People or Structures to a Significant Risk of Loss, Injury or Death Involving Flooding, Including Flooding as a Result of the Failure of a Levee or Dam

Primary Study Area

No Action Alternative Under the No Action Alternative, Temperance Flat RM 274 Reservoir would not be constructed. The existing level of flood control in the primary study area would not change under the No Action Alternative, and no additional risk of loss, injury, or death would be caused by the No Action Alternative.

There would be **no impact** under the No Action Alternative.

Action Alternatives Within the primary study area, the action alternatives would not expose people to a significant risk of loss, injury, or death as a result of flooding. During construction, cofferdams could be overtopped in a large flood event or could fail, resulting in a flood wave into Millerton Lake, and potentially affecting surrounding people or structures.

There is also the potential that Temperance Flat RM 274 Dam could fail, resulting in a sudden release of stored water into Millerton Lake. Details regarding the flood carrying capacity of Temperance Flat RM 274 Dam and the cofferdams are provided in the description of the extended study area impact in the following section. The dam would be designed and constructed to current standards and specifications, including those related to dam safety, minimizing the probability of failure.

This impact would be **less than significant** under the action alternatives**.** Mitigation for this impact is not needed, and thus not proposed.

Extended Study Area

No Action Alternative The risk of failure of Friant Dam, and the associated potential for loss, injury, or death downstream, would not change under the No Action Alternative. Flood system improvements along the San Joaquin River below Friant Dam are anticipated under the No Action Alternative as part of the SJRRP, including modifications to San Joaquin River flow conveyance features below Friant Dam.

A flood routing study performed by Reclamation indicated that under the No Action Alternative, Friant Dam would be overtopped by 1.2 feet for 10 hours during the 500-year flood and by 11.2 feet for 62 hours during the Probable Maximum Flood (PMF), assuming the simulation began with Millerton Lake at the bottom of the flood control pool (Reclamation 2009a). The risk of failure of Friant Dam, and the associated potential for loss, injury, or death downstream, would not change under the No Action Alternative.

As channel capacity and levee improvements are made, releases from Friant Dam will increase to full Restoration Flows. As releases from Friant Dam increase to full Restoration Flows, Reclamation will take measures to avoid increases in the risk of flood damage or levee failure due to under-seepage, through-seepage, erosion, or land-side slope stability issues. Risk of flood damage or levee failure will be minimized by only increasing Restoration Flows when sufficient channel capacity exists, and by closely monitoring and performing maintenance and/or reducing Restoration

Flows as necessary to avoid erosion-related impacts (SJRRP 2012). Additionally, Reclamation will take measures to avoid impacts related to groundwater seepage, as described in the Seepage Monitoring and Management Plan (SJRRP 2013).

Under the SJRRP, channel modifications will be taken to provide full Restoration Flows, also resulting in reducing flood risk in the San Joaquin River.

This impact would be **less than significant** under the No Action Alternative.

Action Alternatives Under the action alternatives, Temperance Flat RM 274 Dam and the construction of cofferdams would be designed and constructed to current standards and specifications, minimizing the probability of failure. The additional storage provided by Temperance Flat RM 274 Reservoir would reduce the magnitude and frequency of flood releases from Friant Dam and therefore lower the potential for loss, injury, or death involving flooding in the extended study area.

A flood routing study performed by Reclamation indicated that under the action alternatives, Temperance Flat RM 274 Dam would not be overtopped by the 500-year flood and would be overtopped by approximately 12 feet for 51 hours during the PMF (Reclamation 2010). During construction of Temperance Flat RM 274 Dam, a 25,000 cfs diversion tunnel would be constructed that would convey the 10-year flood past the cofferdams enclosing the construction area. Flood flows would still be conveyed to Millerton Lake, and the cofferdams would be able to withstand a 3-day duration, 150-year event before being overtopped (Reclamation 2013a). Temperance Flat RM 274 Dam and the cofferdams would be designed and constructed consistent with the latest standards and regulations to minimize the likelihood of a failure that could result in a large release of waters stored behind the dams.

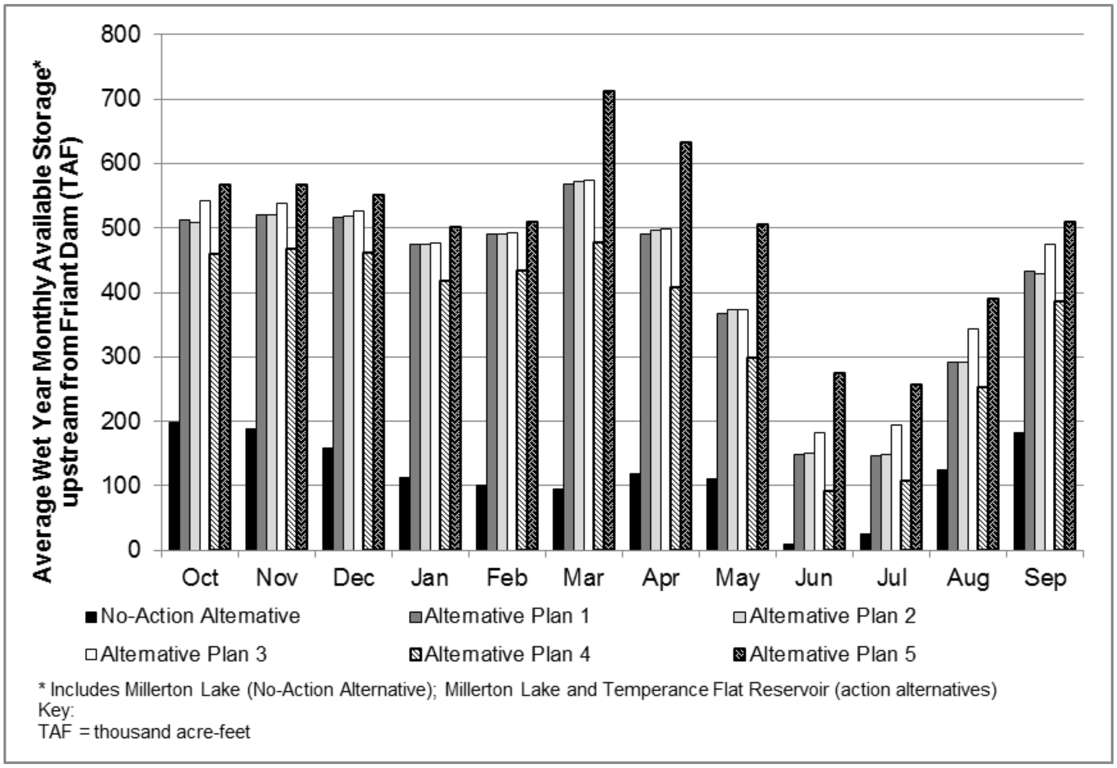
Temperance Flat RM 274 Reservoir could provide additional storage space in Wet years, as the reservoir would likely not be full and the available storage could be used to store additional flood flows that would otherwise have been released under the No Action Alternative. The action alternatives are anticipated to provide several hundred TAF of additional storage in Wet years. The additional storage provided by Temperance Flat RM 274 Reservoir under the action alternatives would reduce the magnitude and frequency of flood releases to the extended study area, as shown in Figure 12-4 (existing conditions) and Figure 12-5 (future conditions), and Table 12-5 (existing conditions) and Table 12-6 (future conditions).

Temperance Flat RM 274 Reservoir is expected to provide additional storage for flood management and provide a beneficial impact by reducing downstream flooding.

As previously mentioned, channel modifications undertaken by the SJRRP will further reduce flood risk in the San Joaquin River. The action alternatives would reduce the frequency, magnitude, and duration of Friant Dam flood releases. This in turn could reduce the risk of damage to SJRRP instream and floodplain investments, reduce the rate of downstream unmanaged sand migration and potentially reduce the rate/frequency of required sand removal at flow control structures, and increase flexibility for managing riparian recruitment flows and flexible flow periods.

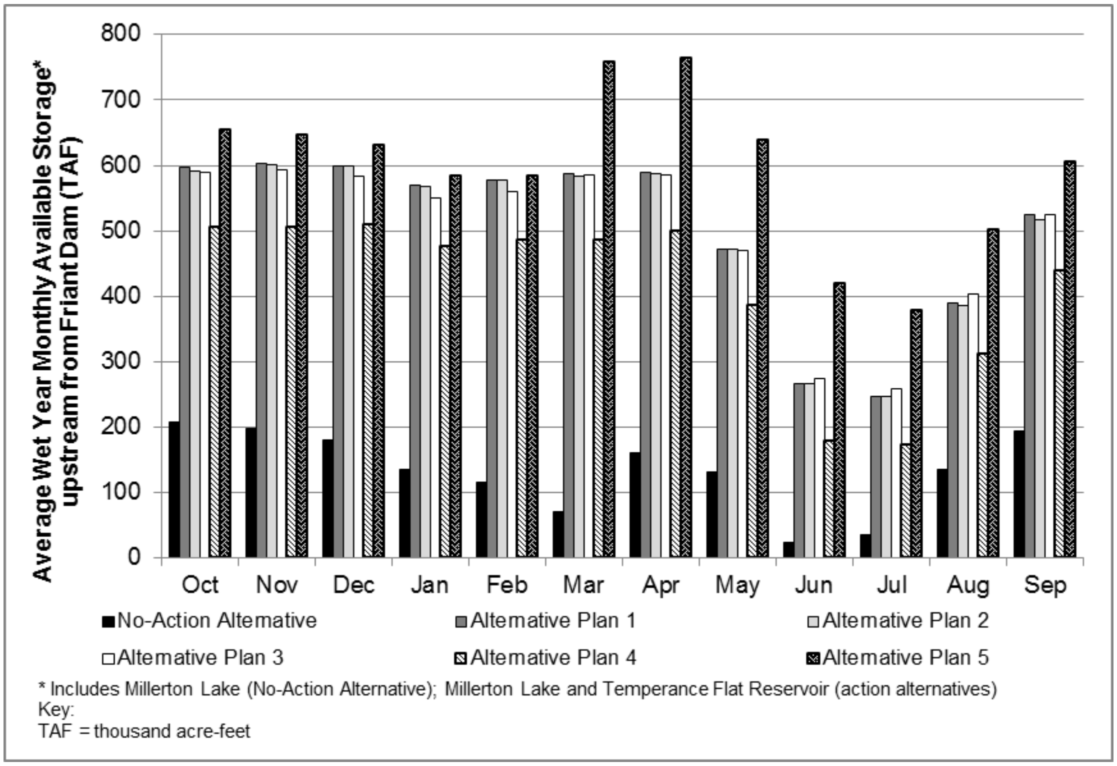
Portions of the San Joaquin River between Friant Dam and the Merced River have historically experienced groundwater seepage to adjacent lands associated with flood flows. Groundwater seepage and associated rises in the groundwater table have the potential to cause waterlogging of crops and salt mobilization and accumulation in the crop root zone. Under the action alternatives, some surface water supply deliveries from Friant Dam would be diverted at Mendota Pool. These surface water supply deliveries would be subject to the expected channel capacity modification resulting from the implementation of the SJRRP. Total controlled releases from Friant Dam, including water supply releases prescribed in the action alternatives, would be within the channel capacity design modification included in the No Action Alternative, which would accommodate full Restoration Flows. Water supply deliveries to Mendota Pool under the action alternatives would be subject to prior water rights and consistent with the SJRRP Seepage Monitoring and Management Plan (SJRRP 2013). Therefore, groundwater seepage impacts are not anticipated to occur as a result of implementing the action alternatives.

The impact would be **less than significant and beneficial** under the action alternatives. Mitigation for this impact is not needed, and thus not proposed.



* Includes Millerton Lake (No-Action Alternative); Millerton Lake and Temperance Flat Reservoir (action alternatives)
Key:
TAF = thousand acre-feet

Figure 12-4. Average Available Wet Year Storage Under Existing Conditions



* Includes Millerton Lake (No-Action Alternative); Millerton Lake and Temperance Flat Reservoir (action alternatives)
Key:
TAF = thousand acre-feet

Figure 12-5. Average Available Wet Year Storage Under Future Conditions

Table 12-5. Simulated Flood Releases from Friant Dam Under Existing Conditions

Water Year	Total Flood Release from Friant Dam[1] (TAF) No Action Alternative	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 1	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 2	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 3	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 4	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 5
1922	98	-	-	-	-	-
1923	13	-	-	-	-	-
1924	-	-	-	-	-	-
1925	-	-	-	-	-	-
1926	-	-	-	-	-	-
1927	10	-	-	-	-	-
1928	-	-	-	-	-	-
1929	-	-	-	-	-	-
1930	-	-	-	-	-	-
1931	-	-	-	-	-	-
1932	-	-	-	-	-	-
1933	-	-	-	-	-	-
1934	-	-	-	-	-	-
1935	8	-	-	-	-	-
1936	125	-	-	-	-	-
1937	498	-	-	-	-	-
1938	1,338	641	634	616	758	610
1939	3	-	-	-	-	-
1940	38	-	-	-	-	-
1941	205	-	-	-	-	-
1942	55	-	-	-	-	-
1943	336	-	-	-	-	-
1944	-	-	-	-	-	-
1945	119	-	-	-	-	-
1946	26	-	-	-	-	-
1947	2	-	-	-	-	-
1948	-	-	-	-	-	-
1949	-	-	-	-	-	-
1950	-	-	-	-	-	-
1951	280	-	-	-	-	-
1952	459	-	-	-	-	-
1953	7	-	-	-	-	-
1954	-	-	-	-	-	-
1955	-	-	-	-	-	-
1956	407	-	-	-	-	-
1957	-	-	-	-	-	-
1958	357	-	-	-	-	-
1959	-	-	-	-	-	-
1960	-	-	-	-	-	-
1961	-	-	-	-	-	-
1962	0	-	-	-	-	-
1963	8	-	-	-	-	-
1964	-	-	-	-	-	-
1965	64	-	-	-	-	-
1966	9	-	-	-	-	-
1967	571	-	-	-	60	-
1968	-	-	-	-	-	-
1969	1,722	824	840	810	965	574
1970	11	-	-	-	-	-

Table 12-5. Simulated Flood Releases from Friant Dam Under Existing Conditions (contd.)

Water Year	Total Flood Release from Friant Dam[1] (TAF) No Action Alternative	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 1	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 2	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 3	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 4	Total Flood Release from Friant Dam[1] (TAF) Alternative Plan 5
1971	-	-	-	-	-	-
1972	-	-	-	-	-	-
1973	72	-	-	-	-	-
1974	96	-	-	-	-	-
1975	0	-	-	-	-	-
1976	-	-	-	-	-	-
1977	-	-	-	-	-	-
1978	801	-	-	-	50	-
1979	72	-	-	-	-	-
1980	508	17	13	0	11	-
1981	1	-	-	-	-	-
1982	563	-	-	-	-	-
1983	2,482	2,218	2,242	2,177	2,302	2,314
1984	259	247	252	235	252	254
1985	-	-	-	-	-	-
1986	609	-	-	-	0	-
1987	-	-	-	-	-	-
1988	-	-	-	-	-	-
1989	-	-	-	-	-	-
1990	-	-	-	-	-	-
1991	-	-	-	-	-	-
1992	-	-	-	-	-	-
1993	6	-	-	-	-	-
1994	-	-	-	-	-	-
1995	1,065	385	378	341	395	132
1996	153	19	14	68	28	93
1997	909	385	361	296	419	342
1998	920	227	197	163	276	249
1999	-	-	-	-	-	-
2000	0	-	-	-	-	-
2001	-	-	-	-	-	-
2002	-	-	-	-	-	-
2003	-	-	-	-	-	-

Source: Summarized from CalSim II 2005 simulations.

Note:

[1] Simulated flood releases include releases required to maintain current flood control space in Millerton Lake and releases made in anticipation of imminent large snowmelt volumes that would be required to maintain flood control space requirements.

Key:
TAF = thousand acre-feet

Table 12-6. Simulated Flood Releases from Friant Dam Under Future Conditions

Water Year	Total Flood Releases from Friant Dam[1] (TAF) No Action Alternative	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 1	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 2	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 3	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 4	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 5
1922	25	-	-	-	-	-
1923	9	-	-	-	-	-
1924	-	-	-	-	-	-
1925	-	-	-	-	-	-
1926	-	-	-	-	-	-
1927	-	-	-	-	-	-
1928	-	-	-	-	-	-
1929	-	-	-	-	-	-
1930	-	-	-	-	-	-
1931	-	-	-	-	-	-
1932	1	-	-	-	-	-
1933	-	-	-	-	-	-
1934	-	-	-	-	-	-
1935	-	-	-	-	-	-
1936	33	-	-	-	-	-
1937	346	-	-	-	-	-
1938	1,187	493	500	467	569	513
1939	-	-	-	-	-	-
1940	-	-	-	-	-	-
1941	155	-	-	-	-	-
1942	13	-	-	-	-	-
1943	173	-	-	-	-	-
1944	-	-	-	-	-	-
1945	91	-	-	-	-	-
1946	15	-	-	-	-	-
1947	0	-	-	-	-	-
1948	-	-	-	-	-	-
1949	-	-	-	-	-	-
1950	-	-	-	-	-	-
1951	253	-	-	-	-	-
1952	337	-	-	-	-	-
1953	3	-	-	-	-	-
1954	-	-	-	-	-	-
1955	-	-	-	-	-	-
1956	381	-	-	-	-	-
1957	-	-	-	-	-	-
1958	193	-	-	-	-	-
1959	-	-	-	-	-	-
1960	-	-	-	-	-	-
1961	-	-	-	-	-	-
1962	-	-	-	-	-	-
1963	5	-	-	-	-	-
1964	-	-	-	-	-	-
1965	41	-	-	-	-	-
1966	5	-	-	-	-	-
1967	437	-	-	-	-	-
1968	-	-	-	-	-	-
1969	1,558	642	647	625	787	403
1970	8	-	-	-	-	-

Table 12-6. Simulated Flood Releases from Friant Dam Under Future Conditions (contd.)

Water Year	Total Flood Releases from Friant Dam[1] (TAF) No Action Alternative	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 1	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 2	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 3	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 4	Total Flood Releases from Friant Dam[1] (TAF) Alternative Plan 5
1971	-	-	-	-	-	-
1972	-	-	-	-	-	-
1973	24	-	-	-	-	-
1974	66	-	-	-	-	-
1975	0	-	-	-	-	-
1976	-	-	-	-	-	-
1977	-	-	-	-	-	-
1978	696	-	-	-	25	-
1979	19	-	-	-	-	-
1980	434	-	-	-	-	-
1981	-	-	-	-	-	-
1982	399	-	-	-	-	-
1983	2,318	1,899	1,907	1,870	2,052	1,822
1984	233	221	226	217	227	229
1985	-	-	-	-	-	-
1986	452	-	-	-	-	-
1987	-	-	-	-	-	-
1988	-	-	-	-	-	-
1989	-	-	-	-	-	-
1990	-	-	-	-	-	-
1991	-	-	-	-	-	-
1992	-	-	-	-	-	-
1993	8	-	-	-	-	-
1994	-	-	-	-	-	-
1995	922	246	245	233	323	14
1996	85	-	-	0	-	0
1997	811	298	300	269	318	316
1998	723	59	59	13	112	59
1999	-	-	-	-	-	-
2000	-	-	-	-	-	-
2001	-	-	-	-	-	-
2002	-	-	-	-	-	-
2003	-	-	-	-	-	-

Source: Summarized from CalSim II 2030 simulations

Note:

[1] Simulated flood releases include releases required to maintain current flood control space in Millerton Lake and releases made in anticipation of imminent large snowmelt volumes that would be required to maintain flood control space requirements.

Key:

TAF = thousand acre-feet

Impact FLD-2: Substantially Alter the Existing Drainage Pattern of the Site or Area, Including through the Alteration of the Course of a Stream or River, or Substantially Increase the Rate or Amount of Surface Runoff in a Manner which would Result in Onsite or Offsite Flooding

Primary Study Area

No Action Alternative Under the No Action Alternative, Temperance Flat RM 274 Dam would not be constructed; therefore, there would no changes to local drainage patterns, interior drainage, ponding, or other site specific flooding issues.

There would be **no impact** under the No Action Alternative.

Action Alternatives The action alternatives are not expected to increase runoff from tributary streams or the main stem of the San Joaquin River; however total runoff to RM 274 could increase by contributions from the area of project features due to the removal of vegetation and the increase in impermeable surfaces. Because implementation of BMPs would minimize increases in runoff to RM 274, alterations to the drainage pattern of the primary study area under the action alternatives would not result in new or increased onsite or offsite flooding.

Construction of Temperance Flat RM 274 Dam and Reservoir will change the drainage pattern of the San Joaquin River and tributaries draining into the reservoir. When water levels in the reservoir are high and regional flooding is occurring, sediment from the uplands would be deposited as deltas where streams enter the reservoir. When Temperance Flat RM 274 Reservoir levels are low, streams will downcut these delta deposits. However, because the majority of streams are ephemeral or intermittent, there is expected to be little sediment transport into Temperance Flat RM 274 Reservoir. All water that currently drains to RM 274 would still drain to RM 274 under the action alternatives.

Within the primary study area, the action alternatives would include construction areas, a batch plant, staging areas, construction access roads, a waste pile, a borrow pit, and operations and transmission facilities. Runoff from these areas would be reduced through the use of BMPs that may include earth dikes and drainage swales, stream bank stabilization, silt fencing, detention basins, fiber rolls, sandbag barriers, straw bale barriers, storm drain inlet protection, hydraulic mulch, and stabilized construction entrances. Because implementation of

BMPs would minimize increases in runoff to RM 274, alterations to the drainage pattern of the primary study area under the action alternatives would not result in onsite or offsite flooding.

This impact would be **less than significant** under the action alternatives. Mitigation for this impact is not needed, and thus not proposed.

Extended Study Area

No Action Alternative Under the No Action Alternative, residual impacts associated with construction of the Temperance Flat RM 274 Dam would not occur. Implementation of the SJRRP will alter local drainage patterns, and could create interior drainage, ponding, or other site-specific flooding issues. The SJRRP will take actions to avoid interior drainage issues of proposed levees or other hydraulic structures (SJRRP 2012).

This impact would be **less than significant** under the No Action Alternative.

Action Alternative The action alternatives will not alter the course of the San Joaquin River or alter the rate or amount of surface water runoff downstream from Friant Dam. Likewise, increased runoff from construction-related activities and permanent facilities related to the Temperance Flat RM 274 Reservoir is expected to have only residual impacts in the extended study area because of use of BMPs in the primary study area.

This impact would be **less than significant** under the action alternatives. Mitigation for this impact is not needed, and thus not proposed.

Impact FLD-3: Place Within a 100-Year Flood Hazard Area Structures which would Impede or Redirect Flood Flows

Primary Study Area

No Action Alternative Under the No Action Alternative, Temperance Flat RM 274 Dam and Reservoir would not be constructed. No new structures would be constructed within the primary study area that would have the potential to impede or redirect flood flows.

There would be **no impact** under the No Action Alternative.

Action Alternatives Under the action alternatives, Temperance Flat RM 274 Reservoir would inundate portions of ephemeral creeks between Millerton Lake and Kerckhoff Dam. Temperance Flat RM 274 Dam would be constructed to pass the PMF. Some structures, including Kerckhoff Powerhouse and Kerckhoff Powerhouse No. 2, as well as campground facilities, would be inundated. However, these facilities would be decommissioned and/or relocated before inundation.

There would be **no impact** under the action alternatives. Mitigation for this impact is not needed, and thus not proposed.

Extended Study Area

No Action Alternative Under the No Action Alternative, reservoir operations for downstream flood management objectives would not change.

There would be **no impact** under the No Action Alternative.

Action Alternatives Under the action alternatives, reservoir operations for downstream flood management objectives would not change. Each action alternative would provide the same required flood control space, spread between Millerton Lake and Temperance Flat RM 274 Reservoir, as under the existing *Friant Dam and Millerton Lake Report on Reservoir Regulation for Flood Control* (USACE 1980). No structures downstream from Friant Dam would be placed within the 100-year flood hazard area that would impede or redirect flood flows as a result of the action alternatives.

There would be **no impact** under the action alternatives. Mitigation for this impact is not needed, and thus not proposed.

Mitigation Measures

No mitigation is required for Impacts FLD-1, FLD-2, or FLD-3 in the primary and extended study areas under the action alternatives, as there would be no impact or these impacts would be less than significant for all action alternatives.

This page left blank intentionally.